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Engineering in the United States

A REPORT

To the Electors to the Gartside Scholarships on the results of a Tour in the United States in 1904-05.

BY

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PREFACE.

This Report is the outcome of twelve months recently spent in the United States as Gartside Scholar of the University of Manchester.

As an engineer, the writer naturally devoted most attention to engineering, and in particular to mechanical and electrical engineering. In order to come to close quarters with American engineering, the writer thought it desirable to spend some time as a worker in a manufacturing works and in a power station. The remainder of the time was spent in visiting works and educational institutions, interviewing business men, attending engineering meetings and general study connected with the business on hand.

No reference is made in the body of the Report to the St. Louis Exhibition, which the writer visited early on his tour. To attempt a description of it would take up too much space. Perhaps the most enduring impression was that of size: it was distractingly big.

In general the writer was received with kindness by American business people, and freely shown those things which one could legitimately expect to see. The idea, however, that an American will show the outsider *everything* is quite erroneous. He has no more desire than the Englishman to give the results of his special study and experience to the world at large.

Some firms were kind enough to exhibit to the writer their systems of cost-keeping, and several firms very kindly supplied sample forms, cards, etc. For various reasons it has been decided not to reproduce these forms.

In particular the writer would like to acknowledge the assistance he received from Mr. Grace, Junr., of the Ingersoll-Sergeant Drill Co.; Messrs. Charles Churchill and Co.; Mr. McDougal and Mr. Wm. C. Brown, of Montreal; the Wellman-Seaver-Morgan Co., of Cleveland; Mr. Worthington, secretary to the British Institution of Mechanical Engineers; and Prof. S. J. Chapman, of Manchester. To these and many others the writer is greatly indebted, and had it not been for their kindly assistance the defects of this Report would have been even greater than they are.

FRANK FOSTER.

MANCHESTER,
JULY, 1906.

THE GARTSIDE REPORTS.

The Gartside Reports are the reports made by the Gartside Scholars at the University of Manchester. The Gartside Scholarships were established in 1902 for a limited period, by John Henry Gartside, Esq., of Manchester. They are tenable for two years and about three are awarded each year. They are open to males of British nationality who at the date of the election shall be over the age of eighteen years and under the age of twenty-three years.

Every scholar must enter the University of Manchester for one Session for a course of study approved by the electors. The remainder of the time covered by the scholarship must be devoted to the examination of subjects bearing upon Commerce or Industry in Germany or Switzerland, or in the United States of America, or partly in one of the above-mentioned countries and partly in others, but the electors may on special grounds allow part of this period of the tenure of the Scholarship to be spent in study and travel in some other country or countries. It is intended that each scholar shall select some industry, or part of an industry, or some business, for examination and investigate this comparatively in the United Kingdom and abroad. The first year's work at the University of Manchester is designed to prepare the student for this investigation, and it partly takes the form of directed study, from publications and by direct investigation, of English conditions with regard to the industrial or commercial subjects upon which research will be made abroad in the second year of the scholarship. Finally each scholar must present a report upon the matters that he has had under examination. The reports will as a rule be published.

The value of a scholarship is about £80 a year for the time spent in England, £150 a year for time spent on the Continent of Europe, and about £250 a year for time spent in America.

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Engineering in the United States

CHAPTER I.

General Engineering Policy.

There are some general features of American engineering policy which are worth noting.

Cheap Finish. There is pervading most engineering and constructive work a disinclination to make things excessively strong or with an unduly high finish. This feature is undoubtedly in part due to the considerable amount of pioneering work which has been, and still is being, done. Thus, for instance, when it is desired to build a railway in a sparsely-settled district which cannot have a very great deal of traffic, it is imperative that the railway be built cheaply. Otherwise there will be no railway at all. As, however, population increases the amount of traffic justifies a higher standard of construction. The railways of the Eastern States show this raising of the standard of construction very well. To a certain extent, however, this feature of early constructive work has become part of the settled policy of Americans.

Organisation. Another feature which is everywhere apparent is the American love of organisation. The great industrial combines are striking evidence of this fact, and in a less striking manner the same feature shows itself in elaborate workshop organisation.

The accompanying chart (p. 106) gives the organisation of a firm of engineers in the States employed in the manufacture of electrical machinery of all sizes and some small special machines (A.B. on chart) and equipments. The chart is self-explanatory. One or two modifications had been introduced. The post of foundry superintendent

had been abolished, each departmental foreman being under the direct control of the superintendent. It will be noticed that the immediate control of the manufacturing staff and the commercial staff is in different hands. The engineers referred to among the sales agents are technically trained men who are sent out on the road for orders, and particularly when it is thought that technical knowledge will influence the decision of the intending purchaser. The territorial agents referred to are the permanent agents installed in offices in the larger towns and constituting the headquarters for the surrounding territory. The special sales agent is, as the title would imply, sent to any point where his services may be deemed necessary. The order in the columns does not indicate any connection other than being under the same official. Thus under "secretary and treasurer" we have six departments independent of each other except through the above official. The firm employed about 500 men in the works.

Education. In America, too, we find a more persistent attempt to make use of theoretical reasoning in manufacturing operations. The generally friendly attitude of employers towards technical education illustrates this, although it must be remembered that many employers are on the look out, not so much for technical knowledge in their assistants as for special executive and general ability.

It is perhaps in the electrical industry that we find the employers making most use of scientifically trained men, largely no doubt because the electrical industry is to a large extent new and half-developed. There is not that same body of past experience which is at the base of all rule-of-thumb and empirical methods of design, in the electrical industry that there is in many of the others.

Protection. The more strictly national policy of

Protection, and the widespread belief that high prices are an essential to commercial prosperity need not be discussed here. The United States, with its large population and an area of thirty times that of Great Britain; with climates and soils suitable for the production of almost all kinds of mineral, agricultural and manufactured goods, is less influenced—in a direct manner—either one way or the other than is Great Britain by the nature of its policy with regard to international trade. The worst effects of the policy of Protection in the States are probably the indirect ones; the assistance it gives to industrial monopoly and the serious blow it aims at the purity of political and public life.

It may interest English readers, however, to know that there is a strong sentiment in the States that the Tariff ought to be reformed. The American Tariff Reformers, however, want a reduction in the Customs' duties. Nothing the writer saw or heard in the States impressed him as in any sense making Protection a desirable thing.

Americans as a nation know less about the economic principles which govern trade than even Englishmen. As recently as the presidential election of 1904, Vice-President Fairbanks quoted with approval a speech of Lincoln's to the effect that whereas when they bought twenty dollars' worth of steel abroad they obtained the steel and parted with the dollars, yet by buying the steel in the States they obtained the steel and kept the twenty dollars.

High Prices. The belief that high prices are necessary to industrial prosperity is due, of course, to the fact that brisk trade means, as a rule, a strong demand and consequently has an upward tendency on prices. The Americans mostly imagine that it is the high prices

which make the brisk trade, or, in other words, that the horse goes up hill because the cart pushes it.

Specialisation. America is supposed to be the home of specialisation, and undoubtedly—in the engineering trades at least—it is more so than England.

It is true that there is a strong tendency for a firm, unless very large, to confine itself to one branch of engineering, but the close specialisation which concentrates on one single article is uncommon.

The arguments in favour of specialisation are :—Firstly, that the concentration of thought and attention on one or two specialities results in their highest development; and, secondly, that the manufacturing of great numbers of identical articles enables the manufacture to be systematised and improved, with, consequently, a great reduction in the cost of production.

That there is some truth in these claims will be granted; but there are some arguments on the other side which require to be noticed.

All branches of trade suffer fluctuations and a firm engaged in two branches may often reasonably expect that both will seldom be at the extremes of slackness or rush together. Provided then, that these two branches are fairly closely allied in nature so that the men and machines can mostly be employed on either, the chances that a trade depression will seriously affect the firm are reduced.

In order that the full advantages of such an arrangement should be attained, two things should be aimed at.

In the first place, the two branches should not be industrially dependent on each other. That is to say, the state of trade in the one must not be considerably dependent on the state of trade in the other. If this is

not attended to the chances are that when one branch is depressed the other will be also, and the advantages of a combined business are missed.

In the second place, the plant required for manufacturing purposes in the two branches should be as nearly similar as possible, so that it can be used for either. Thus, the combining of two distinct and different industries under one firm, whilst it may somewhat equalise the dividends, will not do anything towards increasing them.

On the other hand, if the plant and staff—including workmen—can be engaged on either or both, then a considerable saving in machinery, buildings and general expenses can be secured, besides some little saving in the wages bill and a reduction in unemployment.

The importance of this point is not sufficiently understood. As a rule, when a firm engages in two branches of an industry, these branches are closely allied; as, for instance, the manufacture of steam engines and condensing plant. When one branch is slack the other is likely to be so also.

There are, however, advantages in running closely allied branches, mainly of a commercial character, although also connected with the design.

When a firm engages in two distinct branches it is advisable that the firm be a large one (having regard to the nature of the work, of course, as well). Otherwise there will not be enough specialisation, or partial specialisation, on the designing side to enable the best designers to be obtained, and the character of the work is apt to suffer a little. Few designers and draughtsmen are experts in many things; a certain amount of specialisation is necessary if the best results are to be obtained.

At the same time, the idea that concentration on one

single thing to the exclusion of all others is the best way to develop that thing is, the writer believes, a fallacy.

Development and improvement in manufacture require the annexing of ideas from other fields and the pushing forward into new fields. This requires a considerable general knowledge, particularly of allied subjects, and a keen receptive intellect. Neither of these things is obtained by a too intense concentration. One of the great advantages of technical societies and periodicals is that they widen one's outlook in technical matters.

Extreme specialisation is most suitable where the demand for the product is fairly regular or where considerable stocks can be carried without loss, thus enabling the inequalities of demand to be smoothed out without greatly disturbing the manufacturing itself. In any case the firm, whilst specialising, must be prepared to make radical alterations in its specialities if it is not going to get "left" some day.

Specialisation and the Workers. Specialisation is interesting when looked at from the workers' point of view, and it is not wholly advantageous.

The greatest argument in its favour is, of course, that it makes for economy of production and that ultimately the working classes receive their share of this improvement. Any improvement which will enable one man to do what required two men before, is a gain to the community, including the workers.

One advantageous feature—which has, however, some drawbacks—is that it opens up a considerable field for unskilled or only semi-skilled workers. Not that all specialised processes require such workers; many indeed call for the highest skill. Still specialisation in general implies two things, viz., (1) repetition by each individual

of some short operation, and (2) the extensive use of automatic or semi-automatic machinery.

The first condition (repetition) means that the *range of skill* required of the worker is less, and hence more easily acquired and in a shorter period.

The second condition (use of machines) means that the *quality of the skill* is reduced because many of the most difficult operations are now performed automatically.

Both these conditions make it easier for an unskilled worker to be draughted into a specialised industry, and for the said unskilled worker the result is practically all gain.

For the skilled worker the gain is more problematical. He may, of course, draught himself into the less specialised branches, in which case he remains pretty much as before. There is a tendency, however, for a considerable number to be drawn into the specialised work.

Often, especially in its earlier development and if on piece-work, his wages will not be lowered; but he is liable to lose, or fail to acquire, some of his ordinary trade-skill, with the result that he becomes much more vulnerable to depressions in his particular trade, and should he be thrown out of work he is at a serious disadvantage in applying for a new job. From the recreative and intellectual side, too, specialisation is a loss to the worker, as it renders his work monotonous and depressing. It makes a worse man and citizen of him.

What, then, are the remedies for these ill-effects of specialisation?

One remedy that is often proposed by labour leaders is that only fully-fledged journeymen should be allowed to run "specialised" machinery. In other words, that the competition of the unskilled workers should be rigidly excluded.

The most obvious objection to this is that it is unjust to the man who is most in need of some consideraion, the unskilled worker. Then, too, the gain to the skilled man, even in the matter of wages, is doubtful, and it does not remove the prime objection—that this kind of work virtually makes a skilled into an unskilled, or, at best, semi-skilled, worker; and by their own claims the skilled man should be paid more than the unskilled.

A partial remedy lies with the workers themselves. If a skilled man is content to become a mere machine tender he will become semi-skilled. He may, however, insist upon varying his work. It is no uncommon thing for American mechanics on repetition work to demand a change at the end of two or three years. If the change is refused, they seek a new job. Often they will stay in one shop and go through a series of processes. This feature is not perhaps so marked in ordinary manufacturing as in specialised engineering work.

Another partial remedy lies in the more extensive use of technical literature and technical schools by journeymen as well as youths.

The effect of rigid specialisation on employment is of importance. As we have seen, the low level of skill required is of advantage in allowing a man to be quickly drafted into the trade, and this tends to prevent unemployment, particularly among the semi-skilled.

Unfortunately, it is necessary at times not to draft men into the work, but to discharge them, and the worker so discharged is too narrow in his skill to find it an easy matter to get a new job. Hence the necessity for such workers receiving a training in something outside the limits of their immediate occupation.

"*Good Enough is Best.*" The claim is often made by

Englishmen and accepted by Americans, that as a rule English manufactures are of a more durable character than those of America.

The American defence is that with the rapid changes in industry taking place the useful life of a machine, say, is comparatively short. At the end of a few years something better is on the market which should be adopted if possible. They make their machines, they claim, durable enough to last until something better is to be had. If they made them too durable they would be too expensive to scrap when something better came on the market.

Like many broad generalisations, this one has some strong points in its favour, but it is liable to be abused if used indiscriminately. Indeed, one thing which is noticeable in the States is that there is a distinct tendency towards making machines and other engineering work more durable. To a certain extent this may be accounted for by the heavier duty required of engineering work in these days.

In connection with American machine tools and machinery generally, one finds a most extensive use of a soft grade of iron which is easy to work, but materially shortens the life of the machines where accuracy of adjustment is essential.

In the abstract this ideal of building for the useful life only, is perfect. There can be no justification in putting valuable labour and capital into a machine only to find that in a few years it is a bar to further progress.

Every engineer can call to mind machinery and plant generally which is out of date, but is kept running because it is still healthy and contains considerable invested capital.

On the other hand, it would be easy for most engineers

to call to mind machines and plant—not always built abroad—which have not lasted as they ought, and other instances again of machines kept in use but of which the annual repair bill is the equivalent of a considerable capitalised sum, or in which efficiency has been unduly sacrificed in order to keep down the initial cost.

It is quite true that "good enough is best," but it all depends on what is meant by good enough. The man who imagines that any sort of a steam engine is satisfactory so long as it will perform its appointed task, and that the measure of its perfection is the smallness of its initial cost, is deluding himself.

The fact is that a principle like "good enough is best" requires a clear brain and expert knowledge in order to apply it to practical cases. The trouble is that some men trust it like a fetish. The man who cannot see the limitations which durability and efficiency impose on first cost is just as much in the dark as he who fails to realise the limitations which first cost imposes on durability and efficiency.

The directions in which American engineers attempt to reduce the costliness of their designs—apart from methods of manufacture—vary with the character of the work to be done, but a few may be indicated.

So far as is practicable cheap materials are substituted for the more expensive ones. Thus case-hardened bushes and pins in locomotives are comparatively rare, the writer was given to understand. Iron pipes largely replace brass and copper in the smaller engine connections; cast-steel replaces wrought-steel to a very large extent, and the softer qualities of cast-iron are much used, mainly in order to reduce the cost of machining.

Less machining and polishing is given to machinery.

On the whole, bearings are properly machined and bedded, although the writer saw some serious exceptions to this rule. Other parts which in England would generally be polished, are merely rough-turned or even left painted. There are two objections to this policy. In the first place, machinery attendants, being human, like a nice-looking thing, and will give more care and attention to a good-looking machine than to a shoddy article. Also machining discovers and exposes hidden flaws, whilst painting and filling do just the opposite. Exactly where the more expensive finish becomes desirable cannot be determined by a broad generalisation.

As a rule Americans make their machinery—and most other things—lighter than we do. They also very frequently pay less attention to the details of construction so far as strength and durability is concerned. Indeed American engineers take more chances in their designs. Some of these risks are taken deliberately, it being held that the extra cost of the superior construction is too big an insurance premium for the risk involved.

Apprenticeship. The old form of apprenticeship so well known in England—although now on the decay—is almost unknown in the States.

Many attempts have been made within recent years to found some satisfactory apprenticeship system, but as a rule with little success.

The age at which a youth leaves school is now two or three years later than it was, say, fifty years ago, so that it is desirable that the old seven-year apprenticeships be shortened. As a matter of fact, four years is about as long as is attempted in the States, even for ordinary apprentices, and this is found to be too long in many cases.

The root difficulty of founding and maintaining a satisfactory apprenticeship system for engineers is due to the fact that a youth can go into a works and after a few months' experience, get a job as machine hand or fitter's helper at considerably better wages than if he were an apprentice. Apprenticeship doesn't pay, and he knows it. This does not apply so much to college graduates, in whose case, however, the training given is as a rule fairly broad, and often very broad, and covers not more than two or three years.

To return to the ordinary apprentice. The writer found that the lure of the dollar, the higher initial wages paid to one not bound to any course of training, was too strong to be resisted by the majority of youths, even though a bonus of £20 or so is often paid at the completion of such a course.

In Milwaukee the writer found that at one shop there was an apprenticeship course for machinists. There were not above half-a-dozen apprentices in the works (employing about 500 men), and none had entered for the year or so previous.

In Cincinnati the writer was told that an apprenticeship system had been in vogue, but that the apprentices found they could earn more as non-apprentices, and not even legal proceedings could keep them to their agreements. Consequently, the scheme was given up.

The Westinghouse Machine Company has an apprenticeship course of three (? four) years for machinists, pay starting at five cents ($2\frac{1}{2}$d.) per hour. These youths were said to be very profitable to the company, and when they had finished their course most of them were discharged in order to show them—as it was put—"that they are not the whole show." Certainly a rather strange ending to a

training the object of which ought to be mainly to ensure an adequate supply of skilled men; and particularly so when one remembers that good all-round mechanics who can undertake new jobs are scarce in the States.

When so many able engineers have tried to find a solution of the apprentice problem, and with such indifferent results, it is not to be expected that the writer can present a cut-and-dried scheme to meet all requirements.

A few points, however, stand out very clearly. In the first place, the apprentice is in most cases worth more to an employer than he is paid, and hence the lack of apprentices may be partly overcome by paying an apprentice what he is worth, which, although not equal to a journeyman's wage, certainly in general amounts to more than apprentice pay.

In the second place, apprentice courses should be much shorter than is now usual. They should be as short as is consistent with the amount of training and experience to be acquired.

Also, piecework (except possibly for a few months during the latter part of the course) should be rigidly tabooed. A youth who is learning a mechanic's art cannot do so properly if he is working under pressure with quantity and not quality as his main incentive. When he has acquired sufficient skill to be allowed to race, it is time that he be either put on a fresh job or made a journeyman. A youth who does a journeyman's work ought to receive a journeyman's pay. Until he can do this work it is bad for him, and ultimately for the trade as a whole, to allow him to make quality subservient to quantity.

Undoubtedly, part of a mechanic's training will in the future be acquired in technical institutions although it is hardly conceivable that the factory training will ever be supplanted.

Probably, too, the old restrictions as to the number of apprentices permitted in a shop of given size will have to be removed, or at least very much relaxed. All that the trade unions ought to demand is that the training shall not fall below some standard. The restriction of the number of apprentices is an injustice to the youths of the nation and therefore to the nation itself.

A good, broad and sound training for the workers is of great importance if a trade is to progress and if the workers themselves are to be rendered less vulnerable to variations of trade.

High Wages and Labour-saving Machinery. It is supposed by many people that the States is the home of the labour-saving machine, and that this is due to the high wages paid.

This is not so, however. As regards labour-saving machines in the engineering trades, the writer thinks that, owing largely to specialisation in manufacture, its use is somewhat more extended than in England, although there is certainly not that enormous difference between the practice of the two countries that is implied by many writers on the subject.

In so far as labour-saving machinery does effect a saving, it increases wages because it produces more to be divided among the people—both workers and employers.

It is not true in general, however, that the use of labour-saving machinery is due to high wages. For

instance, suppose that all wages in England be doubled. Then prices would also be doubled, and the *percentage* saving effected by a machine would remain unaltered, so that it would be just as profitable as before. It ought to be clear to everyone that if these machines really do save labour they will be adopted whatever the money wages. A reduction of, say, 10 per cent. on the wages bill will always be sought after by the employer.

CHAPTER II.

Relations between Employers and Employed.

A FEATURE which often strikes a stranger in the States is the freedom with which the average mechanic will express his opinions to his foreman or manager, particularly so in the western and middle-western states. As illustrating this, we may take an incident related to the writer by the works' superintendent (and half owner) of a well-known machine-tool factory.

A superior mechanic was on a new piece of work and the superintendent was surprised to see that the mechanic had not followed his instructions. Being asked why, he replied in effect, "Because you are a duffer and your method is no good." The superintendent asked him to prove this, and the mechanic did so. "Next day," said the superintendent to the writer, "I raised his wages, but had he failed to show that my method was wrong, I would have discharged him."

Not all mechanics would dare to be so independent and probably few superintendents would be so willing to overlook what would usually be considered downright impudence. Still, there is distinctly less of the master and servant feeling in American workshops than with us. Partly it seems to be due to the general spirit of independence which still lives in the States, and partly it is due to the fact that class disinctions are less marked.

To an English manager such freedom of speech may seem like the thin edge of the wedge which will ultimately

overthrow his authority. Allowance must, however, be made for the fact that the significance of "back talk" in an American shop is much less than in an English one. The American seems to consider it a necessity of his republican sentiments, but generally speaking he does what he is told just the same.

Employees' Suggestions. A good deal has been written about the ease with which an American workman can obtain access to his "bosses" when he has a grievance, and the eagerness with which the employer welcomes his co-operation in inventing improved methods of manufacture and even of shop organisation. Although the writer visited forty factories and over thirty electricity stations, besides working in two himself, he did not see a great deal of this latter feature.

As the chief engineer of one firm—a man personally acquainted with English and Continental practice—remarked: "Human nature is pretty much the same here as in England. When a man is responsible for a design or for the running of a shop he doesn't want to have someone else—particularly a subordinate—come and tell him that he could do it better." The same engineer characterised most of the suggestion schemes as just paper and talk. At another large engineering shop the superintendent told the writer that his firm welcomed suggesions; but on being pressed for details he stated that these suggestions were not paid for in cash, but that the man who made them would be remembered when promotion time came. This method when applied to the ordinary workmen, most of whom never get any promotion, can hardly be considered either very just or politic.

At one place where the writer worked, he was told by a departmental foreman that suggestions would be

welcomed, but when he attempted to make one or two to the general foreman they were simply not listened to. The man with whom the writer was working remarked: "Don't you say anything; they don't want to know what you think"; and it seemed as if the man was right.

The writer's conclusion is that the comparatively small number of men who trouble to make well-considered suggestions, the number of these that are worthless, and the natural objection which foremen and managers feel to being told their business by their industrial inferiors, has prevented the adoption of suggestion schemes on anything like an extended scale.

The common idea that the present methods of minute specialisation in manufacture, by which a man may do nothing but make screws or attend to a few automatic machines, are conducive to inventiveness on his part seems to be unsound in logic and disproved by the actual facts. Such monotonous work tends rather to deaden the brain, and to make the man's thoughts run in a groove rather than to arouse any great interest in his occupation. How many people who habitually use the same domestic articles at home ever invent an improvement on them?

Then, again, an invention by its inherent nature requires the introduction of something new either in material or mode of action, and the best way to introduce external ideas is to first study them. Invention and design—as distinct from copying to an altered scale,—be they even in ever so specialised a groove, require a wide knowledge of matters related to that under consideration. The man who does many things, but who does them sufficiently often to thoroughly understand them is the man who in general will prove the most inventive. In particular the man should do, or see done, those things

which have a bearing on the process he wants to improve. Consequently, the expert designer, the skilled all-round mechanic, and the foreman who follows the work through many processes, are the men from whom we should expect and do actually get the greatest number of improvements.

The writer does not wish to pose as an opponent of employees' suggestions. Far from it; but facts are facts, and it is desirable to point out the real state of the movement as it at present exists in the United States. Perhaps something may be done to benefit the worker and ultimately the firm as well, by founding engineering societies for the men which should encourage the reading of technical papers and the interchange of ideas, and also arrange for visits to the works of other firms. And, of course, in any case, a firm ought always to welcome any well-considered suggestions, as indeed many do, although such suggestions don't come very often, and in these days of close specialisation and highly-developed shop organisation there is not a great deal to stimulate them.

There is in many English works a certain partnership feeling between masters and men. Often a man will spend nearly the whole of his working life in the one shop. He becomes almost a part of the place, knows all about its personal side, feels proud of its successes and ashamed of its shortcomings. There is not much of this feeling visible in the States. Each man is looking for higher wages, and half a cent (a farthing) an hour increase in pay will induce him to change his workshop. As one employer put it to the writer: "We have no trouble with our men; we are on good terms with each other; but if the firm down the street offered them half a cent an hour more, there isn't one but would accept the offer and leave us without any hesitation."

This sort of thing has its good points which are discussed elsewhere, but it has its defects. A "community of interest" feeling between masters and men is an asset of considerable commercial value, but it may lead to a too great conservatism and objection to change and enlargement which becomes a bar to progress. There is a natural tendency for the firm to become a closed concern to which no outsider need apply. In these days of strenuous competition and rapid change it is practically a necessity that a firm shall more or less frequently go outside for its experts and specialists in the commercial, organising, designing and manufacturing sides, in order that it may get those who, by reason of their education, experience or special ability, have shown that they possess a more than ordinary grasp of some class of work.

Most readers can doubtless name several firms which are to all intents and purposes closed concerns, and which stubbornly refuse to open their doors to the college-trained man because they only want boys or youths who are willing to start at the very bottom and receive their promotion mainly by seniority. This feeling does not exist to any very great extent in the States as yet, and indeed the way in which the various officials and heads of departments change firms is sometimes bewildering.

Welfare Work. Some firms have attempted to discover a substitute for this partnership feeling. They take a more or less paternal interest in their employees' welfare; build them houses; provide girl workers with a cheap hotel controlled by the firm; provide cheap meals; organise social clubs, and generally try to help the employee to mind his own business. Americans as a nation are very individualistic, but in industrial communities there is a so little incentive to healthy individual

effort that some form of co-operative movement is really a necessity if the people are not to drop back into a state of "civilised barbarism."

It is undoubtedly true that social betterment and recreation should as far as possible be initiated and carried on by the workers themselves, but the fact remains that in too many cases no such movement is initiated by them, and in default of internal co-operation external assistance should be welcomed.

When the firm undertake to promote this "welfare work" they should act as far as possible merely as promoters of the various schemes and endeavour to induce their employees to form their own social clubs, their own building societies and their own boarding-house clubs.

Unfortunately, the need of organised welfare work is greatest in the large towns in which it is seldom possible for these organisations to have any great success. This lack of success is due to the distance which many of the men—especially so in America—live from the works, the difficulty in crowded districts of finding suitable facilities for the work, and the great number of counter attractions and distractions in a large town.

It is chiefly in the smaller towns and especially in towns where some one firm is, as we may say, the predominant partner that such welfare schemes can have any extended application. In the larger towns this work is necessarily more restricted and of a somewhat different character. The bulk of the work must be left to outside organisations and those mainly of a local character, although there is no reason why they should not be connected through a central organisation.

Although, as we have seen, there is not a very great deal

of welfare work carried on by American firms, yet in a minor way a good deal is done towards providing conveniences for the men. In the northern states it is quite rare to find a factory which is not thoroughly warmed in winter. Good lavatory and sanitary conveniences are commonly provided, and in some cases they are most elaborate.

CHAPTER III.

Education.

So much has been written about American Education * by those more particularly interested in it than the present writer, that is has not been deemed advisable to attempt an exhaustive account of the subject in this report.

Attitude of the People. One of the things which much impresses most Englishmen in the States is the fact that the majority of Americans not merely "tolerate" the giving of an education to the masses; but actually welcome it as a guarantee of future progress.

It is very seldom—certainly the writer never heard of it—one hears the remark that working-men's children were being too well educated and that some day there would be no labourers and artizans.

On the contrary, the general belief—with which the writer fully agrees—is that although a few may have their heads turned, yet a good general education improves the workman as such, and by giving him the means to more advanced work, ensures a more plentiful supply of capable captains and lieutenants of industry.

Educational Ladder. There is no uniform national system of education in the States, but the lines followed are pretty much the same in different places. Firstly, there is the public elementary school, usually with eight

* See Reports of the Mosely Educational Commission; "Education of Engineers," by W. E. Dalby, in the Proceedings of the Institution of Mechanical Engineers, April, 1903; and "Transatlantic Engineering Schools," by R. Mullineux Walmsley, in the Proceedings of the Institution of Electrical Engineers, February, 1904.

grades or standards. As a rule, the school is a mixed one; boys and girls attending the same classes, save that certain special domestic classes are only attended by girls and some other classes are reserved for boys. The bulk of the teachers are women. Following the public school—which is patronised by most of the upper classes—is the high school, also usually a mixed school. Here the scholars are given a general training in science and arts. Finally, there is the university.

Manual Training High Schools. Of late there has developed what is known as the manual training high school, in which special attention is given to the teaching of subjects requiring manual skill, particularly wood-working. As a rule these schools do not profess to be in any sense trade schools. The manual instruction given is supposed to be purely educational; it is intended to develop keenness of perception, steadiness of hand, and the sense of measurement and proportion in objects; and to stir the seeds of inventive genius in the student.

Some of the enthusiasts who support this system of training make rather remarkable claims on its behalf. We are told that it is not only the best system of developing the intellect with a view to its ultimate use in business and industrial life, but it is also an excellent moral training.

Nothing, they say, so demoralises a man as to be allowed to make an inferior article. These schools insist on good and accurate workmanship; hence, it is claimed, the great moral value of the training.

It is difficult to see why the man who spends a day making a high-class article is likely for that reason to be more moral than a fellow workman who makes two similar but rather inferior articles in the day. The immorality

would be in the representation of the two articles made by the latter as being every bit as good in themselves as the one made by the former. With this side of the business the workman seldom has anything to do.

A few of these manual training high schools are, however, professedly trade schools. That is to say, they aim at teaching a trade so thoroughly, that the student on leaving school shall require very little further training in order to convert him into a fully-fledged journeyman. The majority expressly state that they are not in any sense trade schools. At one such school the writer was informed that probably half the students never afterwards made any direct use of their training at the school.

It is worth noting that trade schools are opposed by most of the Trade Unions. The Unionists object because, they say, the schools turn out a class of superficial workman who is prepared to accept low wages and who may therefore supersede the ordinary journeyman. It is doubtful if there is much ground for this opposition. It is certainly contrary to general experience that the man who has spent two or three years undergoing an expensive training* should work for less wages than the ordinary artizan. As a matter of fact it is generally claimed that the students from these schools become foremen and managers after a short works' training.

This opposition to trade schools is the more undesirable because, in the States, there is almost nothing in the way of an apprenticeship system by means of which a man acquires a fairly broad and sound training.

Another ground of opposition to trade schools by the Unions is that these schools create an over-supply of

* The course at the Cincinnati school, for instance, covers three years; tuition being twenty guineas per year.

labour. The idea on which this argument is based permeates trade unionism through and through. It is the old fallacy that there is only a limited demand for labour and that consequently it is to the interest of the Union to keep down the supply. Provided, however, that roughly equal opportunities are given in all trades for the free growth of a labour supply there is no truth in the argument. Except in cases of large alterations in industry or of temporary trade depression, an over-supply of labour is due to an improper distribution of labour, which may result either from ignorance or selfish restriction of the supply to certain branches.

Technical Evening Classes. There is nothing in the States to equal the excellent technical evening classes so common in England. What few there are, are mostly supported by, or on behalf of, private concerns. The fees are higher than in England and the attendance small, as a rule.

Many Americans are opposed to evening classes on the grounds that a youth who has worked all day is not in a fit state to benefit properly by the teaching; and that it pays the nation better to keep boys at school longer before sending them to work. On the other hand, there can be no question that the public elementary schools do not supply the place which, in England, is filled by the technical and commercial evening classes. In the absence of suitable day classes—and proper facilities for attending them—the evening classes are almost a necessity.

Technical Colleges. With few exceptions the American colleges and universities are strongest on the technical as distinct from the purely scientific side of the training they give. This applies, at least, to engineering education.

Where money has been forthcoming* a great deal has been spent on expensive machinery and equipment generally. Much of it is waste. The mistaken notion that the more nearly the equipment of a college corresponds to that of a conglomeration of factories and the more severely practical it is, the nearer is the educational millenium, is largely responsible for this.

The same criticism would not be without application in England. In many English educational institutions a sort of museum of engines and generators is to be found. But engine tests in an educational institution are not for the purpose of comparing a Browet-Lindley with a Bellis engine, or a Bruce Peebles with a Mather and Platt generator. The constructive details, in nine cases out of ten, count for next to nothing from an educational point of view, and there is this fact always to be kept in mind: that a student may have time to carry through a series of related and really educational experiments on one machine, but if he has to cover three or four in the short time at his disposal, he will acquire little more than a mass of disconnected meaningless data.

In higher educational work, data should illustrate and enforce the underlying principles. Some people hold the reverse to be true: that the principles are only useful to illustrate current practice. This, however, is never wholly correct, and is only approximately in technical as distinct from the higher scientific education. Technical training should be for those who by reason of lack of time or ability—especially the latter—are not competent to receive and make good use of a broader training in the underlying principles or science of the subject.

* The gifts to American universities are officially stated to average about two million pounds annually.

In other words, "technical" training in its limited sense is a training in the *art* of industry. If, however, the industry is to make substantial progress; if it is to take leaps and not merely to crawl from point to point, then its leaders must be men who know the science of the industry and who can see and make use of the connection between apparently diverse things.

Of course, the writer does not want to give the impression that in his opinion technical as distinct from scientific training has no legitimate field. On the contrary, so far as mere numbers go, the legitimate field of technical education—with as much scientific education added as can be thoroughly acquired—is immensely wider than of scientific education. And, too, in view of the obvious fact that even the most advanced students require a reasonable amount of art to be added for direction, illustration and variety in their science, it would be folly to draw a strict line of demarcation.

Still, it is convenient to say that a technical school should devote itself more particularly to the art of an industry, and a university to the science.

It should be pointed out, however, that the word science as here used, means something more than is usually understood.

Science, as commonly understood, is a very limited thing. To calculate the thermal efficiency of a power plant is scientific—in the ordinary sense—whereas to calculate its commercial efficiency—its earning capacity as compared with the maximum possible earning capacity obtainable from an equal expenditure of capital and labour—is unscientific.

Now that is not as it should be. Why is economy of

heat of more account than economy of money and all that money can buy Why is it scientific to design a plant to use the minimum amount of coal, and not scientific to design one to use the minimum quantity of all classes of materials—stone, copper, brick, glass and labour as well as coal? There is no reason except that our knowledge of the principles of this broader science is too meagre to enable us to formulate its laws with the same precision and mathematical accuracy as those applying only to the more strictly physical science.

We can, however, do a great deal to put the commercial or the "cost" side of engineering on a scientific basis. We can demonstrate simple methods of estimating the most profitable combination and arrangement of machines and plant to perform a given duty.

The mere fact that we can only do a little, as yet, is no argument against the teaching of this broader science. One function of universities is to open up new modes of thought and new roads of progress.

The technically trained man is more *immediately* useful in most situations than the one scientifically trained. It is possible, however, to give the scientific training such a form as to partially remove this disadvantage. The great drawback to the recognition of the value of a scientific training lies in the students themselves. A majority of the students who take a university course are better fitted to profit by a technical rather than a scientific training, and on leaving college they at least do not constitute a good advertisement for it. At Cornell, in America, a rigid weeding-out process is followed, so that only the most suitable students get through to the most advanced classes. This proceeding is rather rough on the rejected students, and probably a better method would

be to have a four years' course of study. The first three years would qualify for the ordinary degree, but a fourth year—to which only suitable students would be admitted—would be necessary to obtain the honours degree. An exception to this rule could be made in the case of those who were well advanced on entering the college. Such men would miss the bulk of the first year work, and a three years' course would qualify them for the honours degree.

A feature of American college training which did not favourably impress the writer was the system of "recitation." Briefly, it amounts to this. A student is told to study so much of a prescribed text-book for the next lesson, when he has to answer questions on the portion prepared.

At one university the writer was informed that no lectures in engineering were given except for the subject of thermodynamics, and then only because the professor could not find a suitable text-book. The recitation classes were taken by assistants on the staff, so that the students saw very little of their professor, and the value of his knowledge and thought was practically lost. The university professor should be able to impart something to his students outside the limits of any text-book, and in any case it is a fact which few who remember their own student life will deny, that *all* students learn better if reading is coupled with considerable personal explanation and enlargement on points of difficulty and importance by a person of ability and authority. It is well-nigh impossible for the average student to obtain a true perspective of his subject, to gauge the relative importance of this and that portion, unless aided by some oral explanation and enlargement. Complaint is made that some pro-

fessors are devoting too much time to consulting practices to be able to give a very thorough attention to their students.

Attitude of Employers. Americans have devoted more attention to the art of engineering in the colleges than we have in England, with the result that, as a body, their students are more immediately useful on leaving college, and indeed a college with a good name finds no difficulty in placing its men immediately on graduating, at salaries of from £150 to £250 a year. Allowing, say, 40 per cent. off for the extra cost of living in the States, these salaries greatly exceed anything within reach of the average Englishman on leaving college.

The American employer undoubtedly recognises the value of a technical training, especially when combined with a fair proportion of science. Probably he would welcome the college-trained man still more if his training had included the science of manufacturing and industrial economics. It is a noteworthy fact in this connection that many of the best college graduates are drafted into the commercial and organising branches of engineering.

Workshop Experience. There is one feature, among others, of an engineer's training which the college can hardly hope to supply adequately, although it might do something. There is no more important study for a works' or business manager than the study of men. For one man who can run a body of men there are half a dozen who can run a gang of machines.

One of the advantages of a workshop training to the future manager is that he meets with the men whom he will some day control, on a footing of equality. If he is wise he will study them and their modes of thought. He

will give a sympathetic ear to their grumblings and make a note of their failings and weaknesses, for it pays to know what lubricant will make the human element in a shop run most smoothly, just as much as it does to understand the lubrication of machinery.

The above is a very strong reason why a shop training should not come too early in the career of a young engineer, and suggests that university students had better take the bulk of their shop training after leaving college.

The acquirement of mechanical skill by the college-trained man of ability is of little consequence, although many engineers regard it as the whole thing. The writer well remembers the scorn of a well-known engineer as he told of a Whitworth Scholar who applied to him for a job, and on being asked if he were a turner or a fitter replied that he could do those things but was not an expert at them. "What," exclaimed this eminent engineer, "could the poor man do?"

Recreative Education. There is one phase of educational work which has not as yet been developed as it ought; indeed, it can hardly be said to have been developed at all.

The writer refers to the recreative side of life. How many people have acquired the faculty of spending their spare time with profit and pleasure to themselves and the community? The time is gone for ever when the manual worker was busy from sunrise to sunset, when railways and newspapers were unknown to him, and he was content to work, eat and sleep, and do very little else. Working hours have been shortened and most people have a few hours a day to call their own.

But how many have learned what to do with these

hours? Very few; and in that lies a serious blot on our educational system and a grave danger to our civilisation.

We are awake to the necessity for technical education. We must, too, be brought to see the equally great necessity for a recreative education. Particularly is this so in our large towns with their dense slums, their hustle, their unhealthy excitement and their lack of those intimate social amenities which do so much to keep the average man clean and healthy minded.

It is true that a little has been done towards giving children a recreative education. Nature study is now quite popular. But nature study is no solution, although it may be part of the solution. Any solution must be broad and simple. Broad that it may link up all classes, and simple that it may appeal more to common sense and our better instincts than to any more or less intimate technical and scientific knowledge.

It is a difficult problem to solve, but it is not too much to hope that some of the enthusiasm and energy which can be aroused by the struggle for industrial progress can be enlisted in the cause of that more important thing in life—living. America is an excellent illustration of the need for a recreative education.

CHAPTER IV.

American Tramways.

THE development of the electric tramway—or street railway as it is usually called—has been so extensive in America that its main features are worth noting.

Practically the whole of the street railways are owned by private companies, although the last two or three years has seen a marked advance in the municipal ownership campaign. The municipal elections of 1905 in Chicago were fought on the question of municipal ownership of the various street railways in the city. The result was a tremendous majority for the municipal ownership party. Owing, however, to legal difficulties, financial obstacles and dissentions among the leaders of the movement, practically nothing has been done so far, towards securing the street railways for the city.

As a rule there is only one street railway company in each town, but in the early days it was no uncommon thing for two or three franchises to be granted to separate companies in each large town. In most cases of such divided franchises the separate companies were merged into one, Chicago being a striking exception, and in a somewhat special sense New York is another.

In the process of amalgamation it, not infrequently, happened that a good deal of water was added to the stock. In one of the very large towns in the States such an amalgamation, or series of amalgamations, took place, and sufficient water was added to prevent the concern making

a dividend, although all the conditions of the service were extremely favourable. The directors no doubt feel quite satisfied, for besides their fees, the process of amalgamation added a few millions to their pockets.

Inter-urban Routes. These street railways are, however, by no means confined to the towns. The inter-urban traffic has been and is being, developed to a remarkable extent. In the state of Ohio, for instance, the electric traction system (on the ordinary roads) is so extensive that sleeping and dining cars are provided on certain routes, and it is possible to travel over 300 miles on the street railway without changing cars.

These very long runs are exceptional and are hardly likely to develop—so far as the actual running of very long single journeys is concerned—to any great extent. What is on the increase, is the development of the street car system between towns of from 5 to 50 miles apart. The cars on these routes are heavier than the ordinary town cars, and much higher powered. Thus one car on the Cincinnati and Indianapolis lines carried four 75 horse power motors, or no less than 300 horse power per car. This car was a double-truck car with provision for inside passengers only. Running speeds of 40 and 50 miles an hour between towns are common, and in some cases between 50 and 60 miles an hour is attained. When running in the towns themselves the car is, of course, slowed down to the ordinary town speed which is usually somewhat higher than that obtaining in England.

On some of these inter-urban roads there are certain stopping places of from one to five miles apart, whilst on others the car will stop at any farm or cross road. Between towns the track is commonly placed to one side of the road and the rails seldom embedded in sets or

ground of any sort, being spiked on to sleepers much as on ordinary steam railroads.

As a rule, the fares are in five cent stages, and are from 20 to 50 per cent. lower than on the steam roads, which latter are generally three cents a mile.

Freight Service. Many of the American street railways, and particularly those with an inter-urban connection, are developing a considerable freight service. To some extent this work serves as a collecting and distributing service for the steam roads, but much of it is quite independent, and to a cerain extent in competition with the steam road. Farmers and tradesmen situated near to the tracks, in particular, find it a help. For this local service it is generally cheaper than the steam road. Special freight cars are often used.

Town Service. In the towns themselves the car service differs in many respects from standard English practice. With one exception (Minneapolis), the writer believes that none of the street railways have adopted the two-decker car. The reasons for this are partly climatic. In the northern states the winters are too severe to admit of outside passengers unless the top deck were covered in. The southern states have, as a rule, followed northern practice. To some extent this objection is negatived by the fact that most of the northern towns have special summer cars open at and entered from the sides, but having no upper deck. In any case, too, the top deck could be covered in.

Another reason given is that the waste of time at stopping places whilst passengers descend from the top would be too great. In England the top is mostly used by men, and it is the inside women passengers who usually delay the cars at the stops. As a matter of fact the

objection of the American to the double-decker is that he does not understand it.

The tendency in the States is towards the double-bogie car as against the single-truck car. The street cars there are so very extensively used—more so than in England—that the traffic density is very heavy, and when coupled with the fact that there is no upper deck, the utility of the larger car is often very marked. The state of the track is generally poor, and particularly so at the points and crossings. Bogie cars, of course, ride over this bad track much more smoothly than the single-truck cars.

All cars in the northern states are heated during winter. In general a stove is used, but electrical radiators are fairly common and hot-water pipes, fed from a boiler on the car, have been used. Inter-urban cars sometimes have lavatory and other conveniences on board.

Standing in the cars is carried to excess. In one small single-truck car in Pittsburg in which the writer was, there were at one time 61 or 62 people (all inside passengers); and in the same town the writer saw cars packed full inside and with three or four youths standing on the bumper round the outside of the back of the car. Ventilation is very defective, although most of the windows open when required.

Power Brakes. A fair number of the cars have power brakes, usually air brakes supplied with compressed air from a small motor-driven compressor carried on the car. These air brakes are nearly universal on the heavy inter-urban cars, on account of the braking power required at the high speeds attained, and for blowing the whistle (which latter is very wasteful of air).

The advantage of the air, or other power brake is that it enables the brakes to be put on or off completely and in-

stantaneously. With the hand brakes the adjustment of the brake shoes has to be so close that it generally happens that they are not fully removed from the wheels immediately on starting up, with the result that considerable power is expended in overcoming their friction. In crowded thoroughfares the brakes are more or less always partially on, as otherwise the driver would not be able to apply his (hand) brakes quickly enough for the conditions of the traffic. With power brakes this waste power due to partially applied brakes is avoided, and owing to the more complete control the driver has over the car, higher accelerations and higher speeds are practicable. Indeed, according to some independent tests made on similarly equipped cars save as to the brakes, it was found that the power required was less for the air-brake car in town streets, but more (only a few per cent.) in the open country, showing that under town conditions the extra power required by the compressor is more than offset by the saving of waste power at the brake shoes. Although most of the cars using air brakes carry their own individual compressors, yet in a few instances—notably at St. Louis—the air is compressed at small power stations situated at suitable points along the car routes—termini, as a rule—and fed into air reservoirs on the cars. The individual compressor is practically a necessity on the long interurban runs where the car service is not very frequent.

With one or two exceptions the overhead trolley is universal in the States. Washington the capital, and New York (Broadway surface cars) are exceptions for which, however, there are special reasons, mainly scenic. At Cincinnati there are two trolley wires per car, one being for the return current. This system is, however, quite obsolete and was installed on account of a clause in

the franchise granted to the tramway company. Immediately the cars get outside the city limits the return trolley is hauled down and the rail return used. In many cases the American street cars carry two trolleys, neither swivelling, and only one being in use at once. Such an arrangement is unsuitable for double-deck cars.

Cable and Horse Cars. Although the electric cars are easily first, there are still a few horse cars (Chicago, San Francisco and New York for instance) on feeder lines and some cable cars, as in Chicago and San Francisco. The cable cars in San Francisco are used on account of the steep inclines in some parts of the city. Those in Chicago have not this justification, nor indeed any justification beyond that of being there. They are a great hindrance to the street traffic of all kinds, and will probably have to give way before long, to the electric cars. The cable system is altogether too liable to stoppages, is too inelastic and a great nuisance at crossings.

Car Speeds. Car speeds in America average somewhat higher than in England, although the writer does not think the difference is anything like as great as some persons imagine, except in the case of inter-urban cars.

Where the American cars do gain on ours is in having shorter stops and higher accelerations. In crowded streets these two factors count for more than high running speeds. We, in England, would do well to imitate the Americans on these points. In particular great promptitude in getting on and off the cars is desirable.

Car Fares. One of the things which strikes a stranger in the States is the system of fares on the street cars. With very few exceptions a city franchise is granted to a company on condition that not more than five cents ($2\frac{1}{2}$d.) shall be charged for one journey whatever the distance,

provided only that it lies within the city limits. These limits are generally very wide and include most of the urban districts attached to the town.

Transfers. In many cases another clause in the franchise requires the grant of free transfers, to which reference will be made later. By the use of these transfers one fare will allow a person to make his journey on two (and occasionally three) different cars connecting at some place stated on the transfer ticket. In Philadelphia transfers cost three cents, or a total of eight cents for one semi-continuous journey. In some towns no transfers are granted at all, but as a rule they are free. In one town (Milwaukee) not only are transfers granted free, but by taking a dollar's worth of tickets at once, the price per ticket is reduced to four cents. Milwaukee has certainly one of the very best car services in the States, certainly infinitely better than its neighbour—85 miles away—Chicago.

Uniform Fare. In none of the towns themselves did the writer come across a fare graded according to the length of the journey.

Undoubtedly this uniform fare system as applied in the States is a dear system, as compared with the service in, say, Glasgow or Manchester. It is true, as we are often reminded by Americans, that in the large towns one may travel a very long way for one five-cent fare. Thus there is, the writer believes, one journey in Brooklyn of no less than 21 or 22 miles, and another in New York of 13 or 14 miles, whilst in several large towns one may go 5 or 6 miles for the five cents.

If people always went the full distance travelling in the large towns would be fairly cheap. As a matter of fact very few people do go the full distance, which is

usually across the town from one outskirt to the opposite. In Manchester or Glasgow the average fare is about 2 cents—one English penny—as against 5 cents in the States. Indeed, it is substantially accurate to say that car fares in the States are from 2 to $2\frac{1}{2}$ times as expensive as in England. Outside the city limits an extra fare of five, ten or more cents, according to the distance, is charged.

The arguments are not, however, all against the uniform fare—*it does not need to be five cents.* Indeed, the writer wishes to recommend the adoption in England of a modified form of the American system.

The chief argument in favour of the American system is economic and social. Under this system it is as cheap, so far as car fares go, to live two or three miles from business as to live one mile. There is, therefore, much less reason for living close to the workshop and office. Undoubtedly this system encourages a healthy growth of the outlying districts.

Consider the average large English town. The car fares from the business quarter to the residential districts vary probably from a penny to threepence. The working man when choosing a house has to give this serious consideration, particularly so if he has a large family. The result is that there is a constant pressure directing his choice towards a house near the centre of the town and forcing him from the outlying suburbs to the grimy, dismal and noisy central districts.

In America things are different. The car fares exert no such pressure, and this fact has undoubtedly strengthened that feature of American housing conditions which is very much to her gain—namely, the com-

parative lack of overcrowding in the large towns (Chicago and New York are rather special cases).

The average American town contains two, or more usually three, pretty well defined districts. In the centre there is the shopping and business district with its tall buildings and every foot of land in great demand; whilst enclosing it and extending away in all directions are the residential districts, in which there is much less crowding together of houses than is usual in England. The third district is devoted to manufacturing. Its location depends on local circumstances.

So far as car fares go it is as cheap to live on the outskirts as near the centre, and the difference in time is not great, provided a fast and frequent service of cars is available. The advantages of living some way out are too obvious to need extensive comment. In doctors' bills alone it is worth a good many dollars a year to the average family. It doesn't pay to live right inside a large town.

The fault of the American system is that it does not accommodate, as it ought, the person who is not travelling to or from his work. There is a great deal of purely local traffic which is not properly catered for owing to the excessive fare charged for a very short journey.

Combined System of Fares. The system which the writer wishes to advocate is that of a uniform fare from the residential to the business districts, in combination with a system of cheap graded fares for local traffic.

The uniform fare between home and workshop or office has for its object the spreading out of the residential districts, and the reduction of rents. The local (graded) fares have for their object the stimulation of the local traffic and the increase in the volume of business done for a given capital expenditure on track, cars and equipment;

particularly during the time when it is most needed, the hours between meals. It is a matter of common knowledge that the more nearly uniformly spread over the day the number of passengers carried is, the cheaper can they be carried. If a car system carries 10,000 people in a day and at the rush hours 2,000 people an hour use the cars, then clearly the equipment must be equal to 2,000 passengers per hour, so that the same equipment (apart from the staff of men) would suffice to carry 48,000 people in the day. In such a case the proportion of the capital charges which each passenger must pay is evidently only about one-fifth what he would have to pay under the former conditions. Under the latter conditions, too, the costs of the staff and motive power would be very largely reduced—per passenger.

In order to illustrate this combined system a little more definitely we will consider a hypothetical case. Imagine a large town of which *B* is the central business and shopping district, *C*, *D*, *E* and *F* are smaller business districts and manufacturing centres, the whole being included within a large area *A*. From each of the sub-centres there runs one or more lines of track to the main centre *B*, at which place all lines connect. Each sub-centre of any size has feeders, and in many cases these feeders will be joined up to form a belt line.

The proposed system of fares is as follows:—For one single fare of a penny—it might possibly have to be more than a penny—a passenger can go continuously from one point to any other point within the limits *A*, changing cars—using transfers—if necessary.

In addition there is a system of local fares of say a halfpenny each. These fares will not, however, allow of anyone coming into the main centre *B* from the outside,

but apply only to purely local journeys. Thus within the area *B* there will be a uniform local fare—with transfers—of a halfpenny, whilst the outside districts—except the larger business areas which would be on the same footing as *B*,—would have a complete system of local halfpenny fares so arranged as not to clash with the uniform penny fare.

The local fares would have the great advantage—from the tramway manager's point of view—of filling the cars in the intervals between meals and thus increasing the ratio of receipts to capital outlay. It is this feature of the combined system of fares which should make possible a uniform fare of a penny in even the largest towns.

Another tramway reform which is very necessary if the trams are to appreciably reduce the crowding together of houses near the business centres, is the speeding up of the car services. This may be done in three ways: by the shortening of the time at the stops; by higher average speeds; and by running through express cars.

The first method is quite feasible, although one may expect a good deal of opposition to it. The second involves the use of larger motors on the cars so that they shall gather way more rapidly after a stop, and would be assisted by the use of a reliable quick-action power brake. The third method will in many cases necessitate special express tracks taken down the quieter streets and having as few junctions, crossings, and curves as possible. Probably in many cases a single express track would be sufficient, the empties returning by the ordinary tracks. The cars on the express track would all be going in or all out of town according to the time of the day. Continuous street speeds of 30 miles an hour would be quite reasonable, after people got used to the cars. These cars would, of course, make

very few stops, and those mainly at the two ends of the run. At present the average speed of our cars is probably not above 6 or 8 miles an hour including stops. The principle of the third track for express service is in successful operation on one of the Chicago street railways.

Transfers. The American system of transfers has so many good points that it deserves a more detailed consideration. Although the details vary from town to town, yet the general principle is the same in all cases.

One car route connects with another at a junction or crossing. The conductor of a car on the first mentioned route will give to any passenger requesting it, a transfer ticket onto the second route. At the point of connection the passenger alights from the first car and boards one going along the other route, as soon as it comes up. The transfer is accepted as a cash fare by the conductor on the second route. As a rule transfers are not granted from one company's lines to those of another, although most of the surface lines of New York City form an exception.

In general transfers are marked with—

(1) Date.
(2) Time (also p.m. or a.m.).
(3) Car route transferred from.
(4) Street along which the connecting route runs.
(5) Direction along connecting route for which the transfer is good.
(6) Transfer ticket number.

As a rule, two punch holes made by the conductor completely determines the transfer, which are dated at the tramway office beforehand and are in colours varying according to the route they are granted from.

To illustrate, consider the following example:—The writer was travelling at about 6-30 in the morning on a

Wells Street and Farwell Avenue car and desired to change at the junction of Farwell Avenue and North Avenue to a car going north at this point. It was the twelfth day of the month. The conductor supplied a transfer ticket previously punched opposite the date 12. He himself punched it at "6-45" and in the "north—a.m." column opposite the line "Farwell and North."

The great advantage of the transfer is that along one car route all the cars—except on the tracks near the centre of the town, which are common to several services—run between the same two points and all are equally available to a passenger who may be going most of the way along another route. Thus a car every 5 minutes means a 5-minutes' service to him, whereas without transfers he must wait for a through car, which may often mean that he has only a 15-minutes' or even a 20-minutes' service. Also, since the transfer is, usually, free he can complete a journey entirely by car, whereas if he had to pay a second fare for a few hundred yards ride, he would partly walk. The transfer system is not difficult to work.

CHAPTER V.

Wages and Prices.

Money wages are undoubtedly higher in the States than in England. On the other hand the cost of living is higher and consequently the ratio of the American to the British money wage is misleading. Still, in general the value of wages—their purchasing power that is,—is probably somewhat higher in the States.

It is difficult to obtain accurate and precise ideas as to wages as one travels about from place to place in a strange country. Particularly is this so in the States, where wages for the same kind of work vary so much from individual to individual. Thus the writer was shown the pay roll of a large engineering firm in the States, and the wages of mechanics on the erecting floor—not foremen or general labourers—varied all the way from 15 to 45 cents an hour, or from 33 to 100 shillings a week. In most shops the variation would be less than this but would still be much more marked than in England. This great difference in wages is a point to be kept in mind, for one is frequently told that, say, "mechanics here earn $3\frac{1}{2}$ dollars a day," whereas in all probability the average mechanic is getting from $2\frac{1}{4}$ to $2\frac{3}{4}$ dollars a day, only a few very good men obtaining the full $3\frac{1}{2}$ dollars. Then again, as in England, there are variations of wages with geographical position. The very large towns, particularly Chicago and New York, pay rather higher rates than the average. The Western states are noted for high wages and high prices, and the Southern states for the reverse.

The writer's own impression of wages in the American engineering trades is that they rule about 50 or 60 per cent. higher, in money, than in England. About 25 cents an hour may be taken as a fair average for the skilled mechanic. This estimate is confirmed by the figures of the American Department of Commerce and Labor in their report on wages in the United States and Europe,* from which the following table has been abstracted.

WAGES AND HOURS IN EUROPE AND AMERICA.

WAGES.

Country	Black-smiths	Boiler Makers	Carpenters	Iron Moulders	General Labourers	Machinists
United States.	100·0	100·0	100·0	100·0	100·0	100·0
Great Britain.	59·0	60·4	56·4	58·9	60·8	62·0
Germany	41·9	39·4	36·2	—	47·6	48·4
France	55·2	51·1	43·0	43·1	57·6	49·0
Belgium	—	26·4	19·8	22·8	32·8	—

HOURS.

Country	Black-smiths	Boiler Makers	Carpenters	Iron Moulders	General Labourers	Machinists
United States.	100·0	100·0	100·0	100·0	100·0	100·0
Great Britain.	94·9	95·4	101·4	94·5	93·1	95·6
Germany	105·9	106·7	111·8	—	99·9	106·9
France	106·4	109·4	121·3	105·6	106·4	109·6
Belgium	—	106·7	130·9	105·6	111·7	—

In this table wages and hours in the States are taken as 100, and of course the wages are merely the money values. It will be noticed that England leads the European countries (these figures refer to the year 1903).

Prices. The value of a wage lies in what it will buy

*Bulletin of the Bureau of Labor, No. 54, September, 1904.

and hence the question arises as to how American and English prices compare. This question is very difficult to decide, except to say that in general prices rule distinctly higher in the States. It is all important in this matter to take into account the quality of the goods. Three pairs of shoes, for instance, at three dollars per pair, are more expensive than two pairs—in the same time—at four dollars. As regards shoes (boots), it may be said that a good quality English shoe is at least 50 per cent. cheaper than the same shoe in the States; indeed, two shoemakers in the States estimated the value of the writer's English boots at double what they cost.

Clothing, especially good clothing, is from 50 to 100 per cent. dearer in the States than in England, which is not to be wondered at when we remember that most of it comes from England, and pays freight and tariff in transit. The writer understands that a similar observation applies to the better classes of household linen. Travelling is much dearer than with us. Distances are generally very long, and railway fares mostly three cents a mile, with very few reduced fares, and some extra fares. What is probably of more consequence to the ordinary workman is the heavy cost of local transport. Tram fares are uniformly 5 cents (2½d.) or more. Most of the smaller items are expensive, although in the eastern states newspapers at one cent each are plentiful. Rents are high. The average working-class family in the northern states spends from 14 to 15 per cent. of its total income on rent, or from £20 to £27 per year,* and the house used by these people has about five rooms per family. Considerably more is paid in the west and less in the south.

*The writer does not know whether these figures include rates or not.

All things considered, the American workman is probably somewhat better off than the English workman. When, however, we take into account difference in the qualities of goods and of prices the difference is not very great; indeed, some Anglo-Americans with whom the writer discussed this point were doubtful if the American had any advantage.

The question arises as to what is the reason for the higher wages in the States.

Is it due to the American being more energetic and competent than his British brother? On this point the *Bulletin of Labor* previously referred to gives some most instructive figures. An official investigation was made by the United States Government and data obtained from 25,440 families, with detailed reports of expenditure from 2,567 families. All these families were resident in the States. In the first place the total income of a family was highest when the head of the family was of Scotch birth. Then follow in order families from England, Wales, Canada, Ireland, Switzerland, Sweden, Norway, Denmark, France, Germany, and the United States. After this come families from "other foreign countries," (*i.e.*, general, unclassed), Holland, Austria-Hungary, Russia, and finally Italy. The figures are given in the table below as also the amounts earned by the heads of the families alone. In this latter case Scotland still leads, closely followed by England and Sweden, then Denmark, Norway and the States. Clearly there is nothing about the natural ability of the Englishman which will account for our inferiority, such as it is. Indeed, it is the general experience in the States—which is fully confirmed by the table below—that the Englishman is at least as good a workman as anyone to be found in the States.

EARNINGS OF AMERICANS ACCORDING TO COUNTRY OF ORIGIN.

Country of origin.	Earnings per year: pounds Whole family.	Head of family.
United States	155	127
Austria-Hungary	140	110
Canada	165	126
Denmark	158	134
England	171	135
France	156	121
Germany	155	116
Ireland	161	111
Italy	127	103
Netherlands	141	108
Norway	159	134
Russia	138	110
Scotland	179	136
Sweden	159	135
Switzerland	161	126
Wales	167	126
Other foreign	148	122

It is often urged, however, that the American—in the broad sense of the word—works harder than the Englishman. It is difficult to decide this point. During a considerable portion of the twelve months the writer spent in the States, the engineering trades were very slack and hence workmen were naturally not killing themselves with work. On the other hand the writer worked at two places in which there was no lack of work to be done. If the American workman does work harder than the British workman the difference is not very marked. In all countries individual workmen differ greatly in this respect. Take, for instance, two mechanics on the erecting floor of one of the large electrical firms in

the States, with both of whom the writer worked. One was the leading mechanic for heavy work, and he certainly did not kill himself. The other man was of quite a different stamp, and was indeed a typical American as depicted in the alarmist press. He worked hard and continuously. No sooner had he finished one job—he was not on piece work either—than he sought out the foreman and asked for another job. Overtime he disliked. At least, he said so; but somehow he always got some if possible, and if not asked to stop he would seek out the foreman and ask was he wanted for overtime! Nor was he the only man of that type. Undoubtedly the American system of payment according to worth is an incentive to extra work by those who think the game worth the candle, as a good many do.

Then, too, shops differ. Some shops have a name for hard driving, and an impression gained in one shop may be completely reversed by a visit to another.

On the whole, the writer is inclined to think that the American of all classes works a little, although not a great deal, harder than we do in England. On the whole, too, their hours are longer than ours, many of the works running full time on Saturdays, except during three or four summer months. It is, however, probably in the office staffs that we find the greatest difference from English methods. Here the hours are, as a rule, distinctly longer and the concentration is rather more intense. Whether this is a desirable thing is open to question.

Probably America as a whole is a little ahead of England in the use of efficient up-to-date methods of production, which, of course, will react favourably on wages. Trade Unionists in England, and to a less extent in the States still have an ingrained belief that labour-saving

machinery means unemployment or low wages. This idea has not the same hold in America, and the result is that the newest and most efficient machines get a better chance of showing what they can do, with the result that more is produced and the individual's share of the national wealth—whilst not a greater percentage—is increased. American wages are also favourably influenced by the great natural resources of the States.

It is sometimes claimed that Protection has raised American wages. There is nothing whatever in the claim. It is true that money wages have been raised, but so, too—and to a greater extent—have prices, and it is purchasing power which counts. With her great variety of climates, soils and natural products, her great area of population, the United States is not in a position to be as seriously affected, in a direct way, by a Protective policy as is England. It is, however, the indirect results of Protection which are most injurious in America, and these certainly reduce the purchasing power of American wages quite appreciably.

There is another reason why American wages should be higher than British which the writer does not remember to have seen discussed before. America spends less on military subjects than we do, and hence a greater proportion of her population are left to take part in useful wealth production. Of course, the writer is not going to attempt a criticism of military policy, but the facts are well worth noting and thinking over. Taking normal peace armaments and allowing for the relative prices in England and the States, our expenditure on armaments reduces the (purchasing) value of the wage by about seven per cent., whilst that of the United States workman is only reduced by one-and-a-half per cent., an advantage

to the American of $5\frac{1}{2}$ per cent. Whether this is avoidable or not is another matter.

Payment of Wages. The writer was surprised at the number of engineering workshops which had not adopted some form of piece-work system of paying wages.

The reasons given for this varied greatly. Some classes of work are obviously not suitable for a piece rate method of payment. Purely repetition or manufacturing work is, of course, where the piece-rate system shows up to best advantage. In one large works at Montreal the men were largely French-Canadians, and the manager said that they worked steadily on a day rate (really a hourly rate), and had not enough ambition to make the introduction of the piece-rate system any gain. The work in this shop—a bridge works—was not unsuitable to piece rates. The hourly rates of pay were, however, varied according to the men's abilities—mechanics receiving about 8 shillings a day and labourers from 5 to 7 shillings. Very few were in any labour unions.

At the Dominion Wire Works in Montreal, on the other hand, practically all the men were on piece work, and earned from 42 to 60 shillings per week. Here, again, the writer was told that French-Canadians lacked ambition—to make money—which was in this case attributed to the exactions and repressive influence of the Catholic priests.

At a works in the States where electric cranes are made, there was no piece-work, the chief engineer giving as the reason that, if the men did not work hard enough without it, the management and not the men were to blame.

Apart from the unsuitability of the class of work done, the most usual argument advanced against piece work was the trouble with the men which resulted, particularly

when piece rates had to be cut. We shall see later that ultimately piece rates must be cut.

At one of the large machine tool works in Cleveland, employed mainly on repetition work, there was no piece work, partly because there was a large number of apprentices. At the works of the Cleveland Automatic Machine Co., engaged almost wholly on repetition work, there was also no piece work. The assistant manager said that a good man worked well without a piece rate, and a bad man they got rid of.

Mechanics there were getting on the average about 11 shillings a day—and working five and a half days a week. Tool and pattern makers got about one or two shillings a day more. An expert set a time for each job and a man's wage was settled by comparing his time with the estimated, an allowance being made for extra neatness as against speed.

At the Bradford Machine Tool Co., in Cincinnati, employed solely on repetition work, there was no piece rate. The works' superintendent (and part owner) believed that a premium system did not offer sufficient inducement to the American workman to make him look at it. All hourly rates were based on the man's output during 30 days' observation. The labour costs on the various standard articles being well known, the man was simply paid such a rate that the labour cost remained the same for all men. This, of course, makes the high-priced man the cheaper, because fixed charges will be less per piece in his case.

At the Cincinnati Shaper Co., also employed on partial repetition work—*i.e.*, standard machines sent through the shops in batches—on the other hand, the premium system was in vogue. Another large Cincinnati firm of machine tool makers (Lodge and Shipley) also had the premium

system in operation. At the Westinghouse Machine Co., in Pittsburg, the writer was given to understand that most of the men were on time rates, with a few on straight piece and none on premium rates. At the Westinghouse Air Brake Co., engaged mainly on repetition work, the men are mostly paid straight piece rates. At the National Electric Co., in Milwaukee, most of the men were on time rates, with some engaged on standard work under the premium system.

At the Baldwin Locomotive Works the system of wage paying is unusual. Most of the work is let out at fixed rates to contractors, who engage and themselves pay the men under them. These contractors average from 6 to 10 pounds a week, with a few as much as 20 pounds. The men are mostly paid time rates, and are kept pretty hard at work. They are said to be satisfied and glad to come back after a slack time.

It will thus be seen that hourly rates are the rule in the States, with, however, a fair amount of both plain piece and premium rates.

Objections to Piece Rates. The subject is worth looking into a little more deeply. It is urged against all piece-work systems that the incentive to make a large quantity in a given time blinds both men and employers to the vital necessity for sound workmanship. There is certainly some ground for this objection and particularly so where a busy foreman is expected also to carefully inspect all work done. In many of the larger shops, even where there is no piece work, there is a separate inspector, whose sole duty it is to see that all work is up to standard quality.

If this system is followed out rigidly and thoroughly there is no need for the quality of the work to deteriorate. The inspector must be a honest man in the broadest sense

of the term and, especially when initiating a new piece rate, quality must be rigidly insisted on.

A very serious objection to the ordinary straight piece rate is the frequency with which it is found necessary to revise the piece rate. The friction and ill-feeling thus aroused, culminating sometimes in a strike, has often deterred both masters and men from agreeing to piece rates. It is sometimes claimed that if only employers were less greedy the cutting of piece rates would be quite unnecessary. Undoubtedly there are employers who have an objection to mechanics being allowed to earn more than, say, 50 shillings a week. Any attempt to limit artificially the share of the national wealth to be distributed among the workers can only recoil to the ultimate disadvantage of both employers and employed. This fact was recognised by the engineering employers of Pittsburg when, in April, 1905, they voluntarily gave the men a 10 per cent. increase in wages because of the improved state of trade.

But even if employers were angels and devoutly desirous of maintaining for ever a piece rate when once established of the mutual satisfaction of masters and men, such a permanent state of affairs is *absolutely impossible*. It is fundamentally opposed to the economic needs and demands of the community as a whole, and such being the case either the industry or the piece rate must undergo radical modification. Piece rates have often been cut without just reason; but piece rates cannot be permanent.

What is the aim and object of a piece rate? Is it not to improve the efficiency of production, to induce a man to make more than he previously did? Now, if more be produced per man, then either the quantity sold must increase or—in the long run, temporary fluctuations neg-

lected—the number of men employed on the work must decrease. The latter alternative cannot be a final one. If it was, it would mean that as the efficiency of production increased—as it is continually doing in most industries—an increasing proportion of the able-bodied men would become unemployed. Such a state of affairs is politically and industrially impossible, and if possible it would be the worst thing possible for all industries to reduce the purchasing power of the masses upon whom, ultimately, all industry depends. An engineering works or an iron mine may not sell its products direct to the worker, but if he did not exist to use them precious few of the former would exist either.

Consequently, it is an elementary fact that (considering industry as a whole) increased efficiency of production must be accompanied by an increase in the quantity sold, and this means—as the tendency of prices during the last thirty years has shown—that prices must fall.

To a slight extent the straight piece rate allows of this, because it tends to somewhat reduce the "fixed charges" cost per piece, and also because the piece rate is usually cut before ever it is put into operation. In most cases, however, a cut in the piece rate becomes necessary if the piece-rate system effects the desired end of materially increasing the efficiency of production. We may illustrate this by a hypothetical example. A hundred men are employed in an industry making a certain article; the costs of manufacture and selling price being given below for the original conditions and also for the conditions when an increased efficiency of production has been obtained.

(1) *Original Conditions.*

100 men make 1,000 articles.

Selling price at 100 per piece	= 100,000
Material at 25 per piece	= 25,000
Salaries, works burden, etc., at 50 per piece	= 50,000
Left for labour at 25 per piece	= 25,000
Total	= 100,000

(2) *New Conditions: Piece Rate in Full Operation.*

100 men make 2,000 articles.

Selling price at 80 per piece	= 160,000
Material at 25 per piece	= 50,000
Salaries, etc., at 37 per piece	= 74,000
Left for labour at 18 per piece	= 36,000
Total	= 160,000

We see that the increased efficiency—which may be due to other causes than the introduction of a piece rate—necessitates the reduction in the piece rate from 25 to 18, although the various establishment charges have been reduced from 50 to 37 per piece.

Of course in an industry of any magnitude the influence of an increased efficiency in one firm seldom appreciably affects the output of the industry as a whole, and hence there will be no need to cut the rate so long as the other firms stick to the old methods. The firm which adopts an improved method before its rivals will—if well managed—make a healthy profit. Those who wait until the majority follow suit will gain very little, a point which is, probably, not too well understood in England.

What is badly needed is some recognised automatic

means of cutting piece rates. There are two methods commonly adopted which partially supply this want.

One is the almost universal stipulation made when fixing piece rates that a change in the processes of production shall be accompanied by a revision in the rates. Frequently new methods are devised mainly with a view to securing a revision of the rates.

The other method, which has found some favour during the last few years, is the premium system. There are a number of these systems but the principle of them all is the same. A man is entitled to a certain hourly rate. He is given a certain time—and therefore a certain price—to do a job, and if he does it in less time than this he receives some fraction (usually one half) of the pay saved on the job, in addition to his hourly rate. For instance, his hourly rate is 20 cents and he is allowed ten hours, but only takes six, thus saving four. Then his premium is two hours pay and his pay for the job is six hours pay and two hours pay as premium, or in all 160 cents. This is at the rate of 26·7 cents an hour, whereas if paid on the straight piece rate he would have received the full ten hours pay in the six hours worked, or 33·3 cents an hour.

Of course, it is impossible to devise a premium system which shall fit all the varied industries and branches of industry, and in consequence a premium system will not altogether avoid the necessity for cutting or adjusting rates, although in general it may be an improvement on the straight piece rate in this respect. In another respect, which we shall consider shortly, it is distinctly inferior to the straight piece rate. In most premium systems a man is guaranteed his hourly rate even if he takes more than the allotted time.

In connection with the adoption of piece and premium

piece rates it may be thought that there is no necessity or justice in paying men engaged on the same work different piece rates or different hourly rates. This, however, is not found to be the case, and in this connection it may be interesting to give the experience of an American works making small motor-driven air compressors.

In normal times there were about half-a-dozen men engaged in assembling these machines. All machining was done for them, although a little tapping, fitting of gaskets and final scraping of the bearing surfaces was left for them to do. These men all worked on the premium system (premium equal to half the saving). The prices had been set by watching them carefully when the system was introduced and deducting 25 per cent. from the best time after the men had got into the swing of their work. The time allowed was the same for all the men, but the hourly rates varied very considerably.

It was found that the cost of assembling one of these compressors under the premium system—and all the men earned large premiums—was *less* the greater the hourly rate paid to the man. In other words, even under the premium system, the 35 cents' man was cheaper than the 30 cents' man, and he again was cheaper than the man earning 27 cents. It may be noted in passing that the man who was best at the work was an oldish man with grey hair, who was never in a hurry, but who was very systematic.

Two Functions of a Wage System. This brings out the important point that a wage system has to produce two different and frequently opposing results.

In the first place the pay should be distributed among the men in strict proportion to their value to the employer (who represents the community in this respect). On the

other hand the system should admit of an automatic adjustment of the piece rate with the selling price. The one result requires that rates of pay should increase with the efficiency of the individual; the other that rates of pay should decrease with an increase in the general efficiency of production.

Let us consider the first point a little. The cost of the finished product is due to wages, material, selling expenses and works' burden (including management, interest and depreciation). The only two of these costs which vary with the individual worker are the wages and works' burden. If *A* reduces the total cost of production as compared with *B* by two shillings a piece, then clearly he is entitled to the extra two shillings, although it is frequently said that the employer has a right to a part of the saving. This, however, is not true, for clearly the saving is not due to the employer's foresight, improved machinery or management, since these are the same whichever workman produces the article.

In order to illustrate more definitely, the following example has been taken. The figures in the top line give the times taken by various individuals. The second line gives the works' burden, so that the sum of this cost plus the wages cost should be the same for all the men. In this way the wage per piece and the equivalent time rate have been calculated.

RELATIVE WAGES FOR VARIOUS WORKING SPEEDS.

Time taken......	14	12	10	8	6	5	4
Works burden..	120	110	100	90	80	75	70
Wages	80	90	100	110	120	125	130
Total	200	200	200	200	200	200	200
Time rate	5·7	7·5	10	13·7	20	25	32·5

The above discussion brings out two or three points. In the first place it is clear that speaking broadly, high wages pay for themselves, and that it does not pay to get inferior men at low wages.

In the second place it shows why even when on piece or premium work, old men who have lost their vigour and skill—this does not apply to all old men—are found to be unprofitable and get their discharge.

To turn for the moment to the question of rate cutting. We have seen that the premium system effects a partial and imperfect solution of this difficulty, and that moreover it acts in direct opposition, in most cases, to the proper division of wages amongst the individual workers.

Perhaps the best solution of the rate-cutting problem which the writer has met with is that adopted by the Ingersoll-Sergeant Co. at their Phillipsburg works. Practically the whole works is on piece work. The piece rates are revised once each year at a conference between members of the firm, the office staff, the men and a representative of the Trade Union (although the shop is a non-union shop), and the revision is made with a view to enabling the men to earn about 25 per cent. above their time rate of pay. The rates are only revised at these yearly conferences, and any increase in efficiency, whether due to the men or to improved methods of production, is allowed to go wholly to the men until the next yearly revision. This acts as an incentive to the men, who know that they have up to a certain date in which to make, if possible, fabulous wages.

Payment according to Worth. In the United States to a far greater extent than in England a workman is paid according to his worth, and this is, the writer believes, one reason why piece-work systems have not been more exten-

sively adopted there. A man's time rate of wages is generally fixed by the foreman partly from a knowledge of the man's previous wage and partly by observation. If the foreman fixes the wage too low the man takes the first opportunity to get a new shop, and if on the other hand he receives more than he is worth, he either has to accept a reduction or take an early discharge.

This system is not only conducive to efficiency, but is also just to the men and minimises the evil of unemployment, although Trade Unionists generally oppose it on just the opposite grounds. They still believe that there is, roughly, only a certain amount of work to be done and that it is therefore unwise to allow one man to do more than his "share." All history and common sense teach us that, except in a very restricted sense, this belief is a fallacy.

Unemployment. During the early part of the writer's stay in America the engineering trades were exceedingly dull, and yet the American papers gave more space to comments on unemployment in England than to that in America. It must not be imagined that the States is without its unemployed; but there are some things to be learned from the Americans in this matter. Undoubtedly the American has little sympathy with an unemployed man, and particularly so because the unskilled workers (who suffer most) are largely Italians and other "foreigners."

An official report based on returns from 25,440 families in the States during 1903, when trade was brisk, shows that half the workers (49·81 per cent. to be precise) were idle at some time or other during the year, and that on the average those idle were idle for about 9½ weeks in the year. The table of causes is interesting. "Unable to get work" accounts for one-third, whilst slackness of work and

similar causes account for nearly one-fourth; so that more than half of them were in the ordinary sense of the word "unemployed." Assuming that the idleness is uniformly spread over the year it amounts to nine per cent., a high figure when we remember that the families considered were representative working-class families. Leaving out sickness, vacations and the like the percentage unemployed drops to about five.

The reader is warned against comparing these figures too closely with the returns made by British Trade Unions. The most serious sufferers from unemployment are the unorganised, unskilled workers, who are included in the American figures.

It is difficult to form a correct estimate, but the writer believes that continuous unemployment—and perhaps average unemployment—is rather less in America than with us. This opinion is widely supported by Americans.

There are great extremes of employment in the States, due in part to the natural temperament of the American, but also aided by the Protective tariff, which makes corners, trusts and other price-controlling influences more effective. Protection itself cannot, the writer believes, directly affect the average state of employment. Its effects are indirect and wholly bad. The theory that expenditure or armaments creates employment receives no support from logic or the state of things in America.

The chief reasons for the better state of employment in America are—

(1) Greater mobility of labour.
(2) Greater mobility of capital.
(3) Comparative absence of standard and minimum wages.
(4) Non-enforcement of "exclusive" trade union doctrines.

The influence of the first condition is least in the eastern states, but in most states the workman is very ready to adapt himself to changing industrial conditions. In this he is assisted by the inability—and in some cases the lack of desire—on the part of the Trade Unions to restrict given classes of work to their own particular members.

The standard rate of pay and the minimum wage are responsible for much unemployment. Clearly if an employer has to pay all men a certain wage, which only 80 per cent., say, are worth, the other 20 per cent. will only be kept in place by the necessity of getting the work done by a certain time. If, however, each man is paid just what he is worth there is no more reason for discharging one than another, with the result that even if the total of employment remained the same—and the writer believes that it would be improved—yet unemployment would be more evenly spread and its evils greatly mitigated. Indeed, under such an arrangement it would pay most firms to run short time rather than to discharge a portion of their men. The action of a minimum wage is quite similar. What employer is going to pay, or could afford to pay, a man 35 shillings a week when the man is only worth 30 shillings?

It will be at once objected by Trade Unionists that without a standard, or at least a high minimum, wage they could not effectively bargain with the employers. This is not so, however, for there is no reason why they should not bargain for either a certain minimum average wage or for the condition that at least two-thirds of the men should receive not less than a certain wage.

But, after all, the unemployed in the skilled trades are not so badly off—nor so numerous—as those in the unskilled and unorganised trades, and no solution can be

found to the unemployed problem which does not take them into account.

We cannot go into detail here as to all the real or supposed causes of unemployment amongst the unskilled, but a few points are worth noting. Their case is all the harder because being, as a rule, unorganised, they have no out-of-work pay and no Union to exert a healthy and character-forming influence over them. Chronic unemployment makes a man unemployable.

One cause of this unemployment is the action of the Trades Unions in attempting, with some success, to restrict the supply of labour in their particular trades by restricting the number of apprentices and by confining certain classes of work to certain trades. Such action keeps out many otherwise capable men and leaves them only the ranks of the unskilled, which become too big in relation to the numbers of skilled workers, for it must be remembered that the unskilled depend largely on the skilled for their work. There is a rough and somewhat elastic ratio between the numbers of the various grades which are employed.

There will always be unemployment—although not necessarily suffering due to it—but it can be reduced by abolishing the standard and minimum wages; by abolishing the exclusiveness of the Trade Unions, and by training the worker to adapt himself more rapidly to the varying wants of the community.

CHAPTER VI.

American Engineering Workshops.

It would be easy, were it desirable, to pick out certain American engineering works which are worse organised and equipped than the average British shop. Such a picture could, however, do little good. The presence of third-rate shops in the States ought not to be a ground for satisfaction with and toleration of similar shops in England.

Consequently, it may appear at times that the writer is praising American shops too much and urging British engineers to copy slavishly the American example.

Such an impression would be a wrong one. Indeed the organisation and equipment of an American works is often a different problem from that presented to the British engineer. Climatic conditions are different. Often, local conditions have an immense influence; invested capital in old-established works has to be considered, and the workman himself is a factor not to be ignored.

Most American engineering works are in the northern states, where climatic conditions require careful consideration. All such works—unless there is some special reason to the contrary—make provision for adequately warming the shops during even the severest weather. Hot air is the favourite means of doing this, the air being, as a rule, heated by steam passing through suitable piping arrangements placed in the ducts through which the fan draws the air. Exhaust steam taken from the engines supplying power to the works is often used in these air-heaters.

It is the firm conviction of most American engineers that adequate provision for the comfort and well-being of the workman is an aid to efficiency and a stimulus to willing service. Most recent English works have reasonable provisions of the same character, although many of the older works are very backward and would justify some little capital outlay in this respect. It is not of more importance that tools should be kept in good working condition than that the men should.

Not merely are the works warmed in cold weather, but proper sanitary and other conveniences are provided. In most shops a plentiful supply of drinking water is also provided, whilst lockers for clothing—more particularly for foundry and forge workers—are common. In summer weather some of the shops are cooled by fans, and sun-blinds are common. The writer saw a small jobbing shop in Montreal in which a large slow-speed fan was placed above a lathe and a drill so as to send a gentle draught down on the machinists and partly no doubt to counteract the effect of a smithy fire close behind the machines.

The works of the Natural Food Company at Niagara Falls is often quoted as a model factory. It is beautifully situated amidst fine trees and grass lawns on the outskirts of the town and near to the river. It contains lecture-rooms and dining-rooms for the employees. The girls are provided with free meals and the men pay only ten cents (five pence) a meal, the meals being beautifully served. Elaborate shower and needle baths are provided for the employees, who are allowed one hour a week during working hours in which to use them. The baths are such as a first-class hotel might well envy. In the factory itself the work of the employees is greatly lightened by an elaborate system of machine handling. The building itself is of

yellow brick with an ample supply of large double windows provided—if the writer remembers correctly—with sun blinds. There are four or five stories in addition to the basement. Visitors are welcomed and shown over the factory by paid guides. Indeed the whole thing is probably arranged more with a view to advertising than anything else. For all that the factory is well worth visiting. The cleanliness, the abundance of light, the purity of the atmosphere and the pleasantness of the working conditions might with advantage be imitated in other factories. As another instance of cleanliness in works it may be mentioned that the General Electric Company at Schenectady stop work a quarter of an hour before closing time on Saturdays, the last quarter of an hour being spent in putting everything in its place and cleaning the machines and tools.

At one large electrical works it used to be the custom to stop work five minutes before time so that the men might wash themselves in the firm's time before leaving. So many of the men abused the privilege and simply crowded round the door waiting for it to be opened that the privilege was withdrawn.

These instances and others which might be cited reveal a willingness, indeed a desire, on the part of the employers to consider the comfort and wellbeing of the men, which, in spite of exceptions, is characteristic of America. It may be argued that these things are all done to bring in the dollars and without a thought for their ostensible objects. Possibly, and if it is so, then perhaps our hard-headed British manufacturers will follow suit. When profits and comfort are both increased there is surely no reason for not taking the necessary steps.

One reason why so many of our English workshops are

badly situated and badly laid out, is the fact that they are old and have grown from small beginnings. It is one thing to choose a new site among green fields and lay out an entirely new works, but quite a different matter when the firm is old established, a growth of many years, and the works is surrounded by—in terms of a purchasing price—valuable property.

The question of reorganisation and removal to a new site has then to be faced, and it presents many difficulties, sometimes insuperable difficulties. In the first place there is the question of expense. In a few cases it may be cheaper to remove to a works away from the town rather than to extend an existing works situated in a crowded district, but in most cases it will involve considerably more expense, and in practically all cases a great deal of trouble and inconvenience.

Then there is the vital question of a labour supply. Obviously a works situated in, say, Manchester has a better labour market to choose from than a works situated only a few miles outside the town. Very often, too, many of the older and most skilled men cannot be induced to move outside the town, and even if the men are willing to go there is still the housing problem to be dealt with. Apart from the labour question there are other difficulties. A town office is frequently required and special arrangements are necessary for the transportation of materials and finished goods.

Yet the advantages usually lie with the works away from the centres of the large town. The men are healthier and less jaded; rents are less; there is room to expand, and it is easier to obtain a suitable site with good railway transport facilities, a thing in which many of the older

works are very deficient, but which is of real importance in heavy engineering.

Industrial Areas. With regard to the location of the works, it is a pity that something on the lines of Trafford Park, Manchester, is not more common. An extensive ground space, with ample transport facilities and freed from many of the municipal restrictions and burdens which are only justifiable on account of the presence of dwelling-houses and general business quarters intermixed with the factories, would be a considerable boon to industry.

From such areas dwellings and general business premises would have to be rigidly excluded, as their presence would necessitate the provision of general facilities and the restriction of industrial facilities—in particular railways on the roads—which would destroy the most valuable features of the area.

Dwelling-houses should never overlook a factory. Such a situation has a demoralising and degrading influence on the workers. No man should live within half-a-mile of his workshop.

In such an area as sketched, provision would have to be made for continuous expansion. This would necessitate surrounding, or partially surrounding it by open spaces, in itself a feature of value to the surrounding residential districts. If local authorities were empowered to purchase such areas in the first place, there would be the great advantage that the natural increase in the site values due to the industry of the community would pass into the pockets of the community.

As regards the site for a works, it is worth noting that most of the larger American firms have built away from the central districts of the large towns. The chief

Westinghouse factories are situated round about East Pittsburg, several miles outside Pittsburg itself; and the last branch to be erected—a foundry—is the farthest out of them all. They are all connected by a private inter-works railroad, and have access to the Pennsylvania main line.

The new Allis-Chalmers shops are situated a few miles outside Milwaukee, and the Bullock Company has just removed into a new works a few miles outside Cincinnati and situated in one of the prettiest suburbs. The Buffalo works of the American Radiator Company is situated two or three miles outside the residential districts. At Buffalo, too, the Lackawana Steel Co. have erected a huge new plant several miles outside the town. These instances might be greatly extended, but the above will illustrate clearly the outward movement.

Of course, there are many large and important works within the towns, but these are mainly old works situated in the older established towns, such as Philadelphia. The works of the Baldwin Locomotive Co. is a case in point. In this case, however, one reason for remaining inside the town is the ease with which men can be taken on or discharged without very serious effect on the labour market. In general the American workman is very ready to leave the large towns and follow a firm to the country. He has less objection than the British workman to pulling up by the roots and transplanting, and this makes it easier for a firm to move its works whenever it so desires.

Workshops. As regards the shops themselves, marked changes have taken place in the last few years in America. Many shops built only 10 or 15 years ago are exceedingly dark and often badly off for crane facilities. In all the

more recent shops these features have been remedied and the abundance of light and excellence of the crane equipments are features of the works. Wooden roof trusses, which were responsible for much of the two previous shortcomings have nearly disappeared. Steel trusses, frequently combined with a steel building frame, brick-filling walls, and glass and slate roofs are almost universal.

Of course the best type of shop to adopt will depend upon the conditions, in particular on the nature of the work to be done and the amount of floor space available.

One of the most unique of large engineering works the writer has seen is that of the Baldwin Locomotive Co. at Philadelphia. These shops are situated quite close to the business centre of this very large town. They cover seven city blocks and from the outside might easily be taken for a collection of cotton mills, the buildings being in the main just rectangular boxes in shape with several floors. Thus one may see steam hammers at work and locomotive boilers being riveted up on the second and third floors from the ground. Naturally this kind of a building is not too light and the shops are dirty.

The usual type of engineering shop met with in the States is a fairly lofty building with galleries down the sides and perhaps the centre. The main aisles serve for the machining and erecting of the large work and are spanned by overhead cranes. The side bays and galleries are for lighter work, departmental stores, tool rooms, and the like. In some shops situated well out of town practically the whole of the shops are on the ground floor. The new shops of the Nordberg and the Ingersoll-Sargeant Companies are examples.

In general, a good deal of thought is given to inter-

departmental communication so as to facilitate the rapid progress of material through the shops. A feature which might almost come under the same heading is the works telephone system. Telephones are distributed very liberally. There will be one or more in each office, and several down in the works, usually at least one to each department. All these are put in connection through a small distributing board in the office which also connects through to the external telephone system. The telephone is much used merely for speaking between adjoining rooms in the offices.

Although the use of wood is not very extensive in these days, yet American shops generally have a fire-prevention system, usually including a full equipment of sprinklers and various kinds of chemical extinguishers.

Machine Shops. In most respects an up-to-date American machine shop does not differ greatly from an English one engaged on similar work. The shop is lofty, well lighted, properly heated and carefully equipped with a view to the work on hand.

The lighting by day is largely from the roof, although windows are plentiful and serve to illuminate the side bays under the galleries. At night electric lights are mostly used; incandescent lamps for the machine tools and arcs for the erecting floor and general illumination. Incandescent electric lamps with flexible connections have largely replaced the tallow candle in many shops.

The transport and handling of material receives great attention in most shops. Electric overhead cranes are almost universal, although other and auxiliary apparatus is much used. In particular, small jib cranes, usually consisting merely of a swinging jib and a light trolley, are placed in convenient positions for handling work when setting up on the machines. A small portable derrick is

also found of use in shops engaged on comparatively small work. The overhead cranes usually run on a common set of rails, although in a few cases—notably the Wellman-Seaver-Morgan Co.—there are two tracks, one above the other. The object of the upper track is to allow one crane to pass the other when the latter is held up at some work. Such an arrangement requires a high roof and somewhat expensive crane runways. Crane speeds are not, so far as the writer could discover, appreciably different from those usual in England.

It is unusual to admit the railroad tracks into the shops except at one end of a shop to a sufficient extent to allow of the cars being brought under the overhead crane. Purely shop tracks sunk level with the floor are common and are very useful. Where heavy work has to be handled it is a mistake to make these tracks of a narrow gauge, as they are most needed for the bulkier articles which cannot easily be put on a light hand truck. At the works of the Nordberg Co., in Milwaukee—builders of Corliss engines—these tracks are so arranged that the work, which is placed on a truck, can be run straight up to the tool and drilled or machined without removing from the truck. A similar arrangement is in use at the works of the Westinghouse Co. for drilling the frames of electric motors.

These shop tracks are, however, most useful for communicating, between different aisles or shops. In order to accomplish the same result the crane runways in the machine shops of the Ingersoll-Sargeant Co. extend out into the erecting shop—which runs across the ends of the former—thus allowing work to be quickly passed from shop to shop.

Floors. As regards the floors of the shops, wood (over a foundation of concrete or something solid) is most

common. It is certainly the most comfortable floor to work on. Concrete or stone is tiring to the feet and very cold in winter. A wooden floor has the further advantage that it allows a little local give and thus allows of a machine being well bedded on to it. This of course is most useful in the erecting shop. These wooden floors should have a smooth surface so as to permit of sweeping and cleaning, and also to make it less tiring to the men. A good floor pays.

A novel type of floor is in use for the erecting shop of the new shops of the Ingersoll-Sergeant Co., Phillipsburg, N.J. The floor is of concrete provided with a number of rectangular pits or wells. The longitudinal sides of these pits are ribbed so that boards can be carried on these ribs across the pit at any level. These boards are used in erecting the engines and compressors, more particularly the piping connections below the floor line. The pits can be covered in.

A large floor plate is found very useful for both erecting and machining purposes. In the latter case it is used as a support for the work whilst portable tools are brought up to work on it. Many of these tools are very large and heavy and have, of course, to be handled by the crane. One of the great advantages of the use of a floor plate and portable tools is that it often enables two or more tools to be at work on the one job at the same time, and greatly reduces the difficulties of handling very large work. Most of these tools are held to the floor plate by bolts, although in a few cases electro-magnets provide the necessary adhesion. The latter method is most useful for tools which are too heavy for human support but are not required to remain in one position for very long together. The fixing of the tool in position is very quickly done with a magnetic

grip and where this speed is of little importance, one of the chief advantages of this method is lost.

Tools. As regards the tools used, one finds, of course, that they are almost all of American make. Except in one or two special branches of engineering—notably ship-building—it is very seldom that one meets with a British-made tool. American tools are well known to English engineers, indeed few British shops are without some. It is needless to give here a necessarily brief and incomplete description of these well-known tools. Where they differ from most English tools, is in the greater handiness of the small tools, and their somewhat lighter build. The handiness of American tools is an excellent feature which has of late years inspired our British manufacturers to move along similar lines. The lack of strength and wearing qualities in small American machine tools was badly felt when high-speed tool steels became common. This defect is being made good, or at least the stiffness is being increased, for the writer is not convinced that American tools wear as well as they ought; the iron is too soft and very easily rusts. Of course it is open to question whether it is worth while to make a tool exceedingly durable. The general policy involved is discussed elsewhere, but it may be pointed out here, that tools constitute a rather special case. Accuracy is one of the first requisites in most tools, and in order to secure continued accuracy over a period of years, good wearing qualities are desirable, and in many cases absolutely necessary. On the other hand a tool may become antiquated even though healthy.

As regards the use of special tools for specialised work, the writer was shown a number of universal milling machines in one shop, cutting helical gears. They never did anything else. Asked why special machines without

the other features of a universal miller had not been adopted the reply was that in case of a sale of plant or change of work, the universal miller would sell well, whilst the others would fetch nothing probably. Further, the machines in use being standard articles would not cost much if any more than the specialised, though, simple, tools. This is a view of the question of special tools which is sometimes overlooked.

Automatic machines are, of course, common for some classes of work, but a great deal of repetition work is done on semi-automatics and turret lathes.

The boring mill and milling machine are very common in the States, although, of course, the lathe and planer are still thriving. The field of the boring mill is mainly confined to articles of the wheel or short-cylinder class and particularly for heavy work of large diameter which would be difficult to set and hold true on the ordinary lathe. In the writer's opinion, the main advantage of the milling machine for general planer work is that it has only one idle return stroke whilst a planer has hundreds or even thousands. The milling cutter is working from the time the machine starts until it stops as against about two-thirds of the working time on the ordinary planer. On the other hand, the milling machine will seldom give such true surfaces as a planer. This is mainly due to the intermittent character of the cutting action. The number of cutting edges in action fluctuates periodically by one and sometimes more. This means that the pressure on the cutter varies correspondingly, and being a rotating (and therefore, to some extent, free) tool chattering takes place. The fewer the number of teeth in action at once, the more marked is this action. Fortunately, it is now recognised that each class of tool has special weaknesses

and strong points, and that the blind advocacy of one or the other is undesirable. An engineering works cannot be run by empirical formulæ; sound judgment is necessary for success.

Tool Steels. When the writer went to the States the high-speed tool steels were comparatively new. Some works had not adopted them at all; but in most shops they had made considerable headway, and it was interesting to note that these special steels all came from England.

The chief engineer of a large firm of electric crane builders expressed the opinion that the saving due to the use of the high-speed steels was not more than one-tenth of one per cent. The works used these steels to some extent, but the engineers' objections were that owing to the tearing action of the tool more material had to be left for removal by the finishing cut and that—especially for long armature shafts—the heat generated distorted the work and necessitated time being allowed for cooling. In view of this fact, the extra power required by the tools, and the more expensive machines required, he did not think there was any appreciable gain in connection with light and accurate work. Undoubtedly the high-speed steel shows up to best advantage when taking heavy roughing cuts on repetition work or work in which the time occupied in machining is a large percentage of the total time.

At one works the writer was told that the men were still afraid to use the high-speed steels to their best advantage.

Tool Layouts. As regards the general layout of the tools, it is impossible to make more than general comments. The actual layout is governed by so many considerations; nature of the work to be done, situation and size of shops, age of shops, etc., that each case must be considered on its

merits. As far as possible all useless carrying to and fro of material or work should be avoided. In many works this is secured to a considerable extent, the work progressing steadily along a certain previously determined path through the shops. In the smaller shops it is not so easy to secure this steady progression, and in old shops it is frequently impossible without an entire reorganisation. Where space is available it will be found that a few temporary storage areas in the shops for partially finished machines greatly reduces the needless turning over, rearranging and carrying to and fro of machine parts.

In some works the plan is adopted of grouping machine tools according to their kind. Thus all planers are grouped together, all millers are in another section, and so on. To a certain extent this arrangement forms a part of the previously described "progressive" plan. As a rule the chief advantage of this grouping is that if one planer, say, is engaged another may be free, and thus work can be forwarded to a certain point in the shops without a previous enquiry as to what machines are at liberty. When, however, an attempt is made to group all kinds and sizes of milling machines, say, there is no corresponding advantage as they are unable to exchange work and are, in fact, different machines from the manufacturing standpoint. Also, it frequently happens that the sequence of machining operations is not the same on two classes of work, so that if machines are "grouped" there is bound to be a good deal of carrying to and fro.

Machine Drives. The electric drive is rapidly ousting the engine drive in general shops. All the newer shops have adopted the electrical drive for most purposes. The larger tools are often driven by their own individual motors, whereas the smaller tools are commonly grouped

and have one motor driving a constant speed countershaft from which the separate machines receive their power through belts. The advantages of the group drive over the individual drives are reduced capital outlay and smaller power consumption. The capital outlay is less because one large motor is cheaper than many small ones, because the capacity of the one motor can be less than the sum of the individual capacities—owing to the fact that not all the machines take their maximum power at one time—and the belting is simplified a little. The power consumption is somewhat reduced because of the higher efficiency of large motors and because the percentage average load is increased. For satisfactory group driving a fair number of machines should be combined in a compact space. If long countershafts have to be used they become inefficient.

When the machines are large and spaced well apart, the group drive becomes rather complicated, its economy falls off and its lack of flexibility—the great advantage of the individual drive—makes itself felt.

As regards the type of electric motor, much depends upon the work to be done and something upon the source of power. In most shops the continuous current motor reigns supreme, and takes current at a fixed voltage. The elaborate speed varying devices obtained by having several available voltages are seldom used. They are of no use for group drives where the speed must be maintained approximately constant, and which in most cases constitute the bulk of the drives. Where the individual drive is much used voltage control of the speed is occasionally adopted, although rheostatic control on the field is more usual and promises to become more so as the interpole motors become more widely used. Even in the case of the individual drive the speed control is sometimes quite external to the motor.

In some shops (alternating current) induction motors are used. The relative merits of the various types of motors is too technical a subject for a report of this nature, but it may be pointed out that the induction motor drive is at its best where the speed is not required to vary, where the percentage average load on the individual motors is high, stops are not too frequent, sparking at the motors is dangerous, and where the source of electric power is external to the works and received as alternating current.

Most large American works generate their own electricity, and in such cases, unless there are special reasons to the contrary, the advantages of continuous current are considerable. There is a possibility that an alternating current commutator motor with the general characteristics of a direct current shunt motor, may yet capture a considerable field at present held by the direct current motor when the power is transmitted to the works from a distance. At present there is no such motor on the market.

The writer noticed a considerable development in American machines towards incorporating an electric motor directly with the machine and driving through toothed gears without any intermediate belts. The speed changes are then obtained by change gears, or at the motor itself, or by a combination of the two methods. The method of varying the motor speed is likely to receive considerable impetus due to the reintroduction of the interpole motor. The use of belts in the transmission is still very common, and in those cases where sudden and momentary heavy loads are met with—as in planers and boring mills on wheel tyres—it often saves the gears from breakage which can otherwise only be guarded against by the use of very heavy gears.

The chief advantages of the electric drive are that the

shafting is sectionised, thus minimising the risks of a total breakdown; that great flexibility and handiness are obtained and that it becomes possible to concentrate all the power-generating plant in a central station, where it may receive adequate attention and be kept up to its maximum efficiency. In large shops there is, too, frequently some economy in power. The capital outlay is, however, considerably increased.

The provision of a central power-station where practically all the power generators, air compressors, pumps, etc., are concentrated is growing in the larger works. It is much easier to check waste when the purse-strings—if one may put it so—are all brought to one place and under the observation of one properly qualified person.

Pattern Shop and Store. The pattern store of the ordinary engineering works is a place of considerable importance. Indeed, so far as mere size goes it should be, and usually is, several times as big as the shop in which the patterns are made. As regards the pattern shop, most of the work is of course purely hand done, although woodworking machines are used to a considerable extent. Pattern makers usually get a little better paid than mechanics, and many of them have received a manual training high-school education.

In some of the older shops patterns are just stored "in any old place," but in the newer works the storage and record-keeping is done systematically and in such manner that there is a place for everything and everything is in its place unless in use, in which case a record of its whereabouts is kept. The pattern store of the Nordberg Manufacturing Co. (builders of corliss engines) is a six-storey building standing away from the other buildings. It is provided with an elevator to all floors. The heaviest

patterns of all kinds are on the two bottom floors, which are equipped with small overhead trolleys to facilitate handling. Other patterns are arranged according to their nature. On each floor there is a central passage leading to the elevator. At right angles to this passage are arranged the racks of shelves which again are subdivided into spaces. A record is kept for each pattern, giving the floor, rack, shelf and space, so that the exact whereabouts of a pattern is at once known. A record of the patterns received and sent out is also kept, so that the proper apportionment of the pattern cost may be estimated, as also those patterns which are not used often enough to be worth keeping intact. With regard to the first point it is the practice of some firms to place all but special patterns to the general expense account.

A somewhat similar system of storage is used at the new foundry of the Westinghouse Machine Co., near Pittsburg. A card index system of records is used and if conscientiously carried out is an excellent thing.

In most of these pattern stores considerable precautions are taken against fire, even in one case to subdividing the store into watertight compartments, any of which can be flooded with water if required.

Foundry. Many American engineering works have no foundry of their own. The reasons given for this were usually: the difficulty of making a foundry pay, and the troubles with the moulders' union. Many firms preferred to shift these troubles on to other people's shoulders.

As one would expect, machine moulding is mainly confined to repetition work. Small pneumatic motors for working sifters and riddles are fairly common as also are pneumatic rammers, and pneumatic chisels for cleaning

and fettling castings; this last operation being often and preferably done in a special room.

One difference which at once attracts notice is the use of wooden flasks, which is almost universal. For small work the saving in weight is perhaps worth having, but in the larger sizes it is more problematic, as when the sand is in position the crane is necessary in any case. The chief objection to these flasks is that they get burnt and don't last long. On the other hand they are easily and quickly knocked together. Snap flasks, also usually of wood, are fairly common for small repetition work.

As a rule less care is taken with the formation of the moulds than is usual in England, although much of this must be charged against the designer and pattern maker, who are very fond of square corners.

In the newer foundries great attention is being paid to handling facilities. Overhead cranes are almost universal, often combined with jib cranes. The latter are, however, very seldom planted in the middle of the floor. At the new works of the Ingersoll-Sergeant Co. at Phillipsburg, one of the side bays of the foundry is provided with what is called a rubber neck crane. This consists of the usual overhead traveller, provided with a horizontal beam underneath the length of the crane which can be run out so as to project into the adjoining bay. On this beam is a trolley which carries a ladle, flask or other weight. This crane is very handy for passing work or metal from one bay to that adjoining. At this foundry most of the moulders are young. They work, as a rule, in pairs, one being proficient and the other a learner. When the latter becomes proficient he receives a learner as his assistant, and the man he learned from passes to another section of

the moulding work where he becomes a learner. In this way the moulders receive a good broad training.

The new foundries of the Pennsylvania Railroad, near Altoona, have been very carefully designed. There is a wheel foundry with a capacity of 900 car wheels per day, a steel foundry, a brass foundry, and an iron foundry. The foundries were not quite complete when the writer visited them, although the wheel foundry was running—at one-half its ultimate capacity. This foundry is run on a piece-work basis, the men earning from five to six pounds a week. Each moulder has two helpers and is expected to make 25 wheels a day. The foundry as then existing had a rectangular floor. Along one side was a track running in front of the three cupolas. On this track were coupled together four trucks each carrying a small ladle (filled from a large ladle at the spouts of the cupolas). Along the opposite side of the floor was another track (? duplicate tracks) with four coupled trucks. The moulds are arranged in rows across the floor between the tracks and over each row is an I beam carrying a hoist. Towards one end of the foundry are the annealing pits in four transverse rows, each pit being capable of holding 16 wheels in a pile.

The method of procedure is as follows:—The four ladles are filled with metal and run along the track until opposite the four transverse rows of moulds wanting metal. The ladles are then taken up by the hoists of the said four rows and run over the moulds, which are filled, and the ladles returned. When sufficiently cool to handle—the moulds have chills on the treads and flanges—the same four hoists take the wheels and drop them on the four trucks on the side of the foundry away from the cupolas. These trucks are run together until opposite the annealing pits. Here a crane, which travels over the pits, lifts the

four wheels together by expanding grips inside the hubs of the wheels, carries them over the pits and lowers them in. When the pits are full they are covered in and allowed to cool during two (? four) days.

The other foundries were not complete, but a number of tracks above and below floor level were in position for bringing and removing material.

At the Wilmerding foundry of the Westinghouse Air Brake Co. there is an interesting arrangement for facilitating cheap and rapid production. An endless band or moving platform describes a flat letter O. Alongside this platform at one point stand the moulding machines—all the work handled on this platform is purely repetition work—which receive sand by pipes from an overhead conveyor. The platform brings up the empty flasks. They are removed, placed in the machines, the moulds formed and the halves of the moulds then replaced separately on the platform, which carries them forward Whilst on the platform cores are inserted, the two halves placed together and the metal run in. The moulds are then carried round to the opposite side of the letter O, where they are loosened and being seized by two men, are jerked off the platform in such a manner that the casting (and sand) is ejected, the flasks being replaced on the platform.

The castings are thrown together in a heap to cool. The sand falls through a grating, is moistened and elevated to the mixing floor above, whence it passes once more to the moulding machines.

The men were working in two shifts—7-15 a.m. to 5-40, and 6 p.m. to 6-30 a.m. All the shop was on a straight piece rate basis. The rates had been reduced a month or two previously, but owing to improved trade an increase

was contemplated. The men worked hard and the better of them earned from 30 to 35 cents an hour.

Most foundries use the ordinary cupola, although where the best grades of iron are required some foundries use what is called an air furnace. This furnace is not unlike a steel melting furnace in general outline. It is a reverberatory furnace with an external fire. It takes longer to melt the iron than a cupola.

Foundry work is so dirty that some firms consider it unnecessary to provide washing and other conveniences. Other firms take just the opposite view and provide all the men with separate lockers.

Tool Room. Tool rooms are of two kinds. In one tools are sharpened and repaired; jigs, dies, and small special tools made; whilst the other kind of tool room is simply a store for tools, dies and the like.

In a large works the tool store is frequently split up into sections located at suitable points in the works. As a rule these departmental tool rooms are purely store rooms, the whole of the making and repairing being then done in one tool room. The extent to which a tool room of this sort will do tool making proper varies in different works. Such things as standard gauges, micrometers, and drills are nearly always made by external firms of tool specialists. As to milling cutters, a good deal of difference in practice exists, although it is seldom that a small firm will make its own, largely on account of the troubles experienced in hardening the cutters. Jigs, standard templates, special gauges, dies and small tools of the instrument class are commonly made in the tool room. Some firms, however, do nothing beyond keeping their tools in repair, and others, having no tool room, cannot do even this, with the

result that the economical production of good work is very seriously hindered.

In connection with the tool stores, the workman generally presents his check in person. In several works, however, messenger boys are provided to do all this fetching. The workman calls a boy by pressing a bell push. In some works a record is kept of the time the boy is away from the central office, so as to prevent loitering. The reason for resorting to the use of messengers is, of course, to save the men's time.

Besides supplying taps, drills and the like, these tool stores frequently supply small screws, and similar articles required in the manufacturing work. Such things are, of course, procured by requisition, and not by check. Heavier articles, such as valves and motor parts, are usually kept in the main stores through which all work passes—of course there is a good deal which never enters the actual store room.

Drawing Office. A good deal of attention is generally given to the system for storing drawings, some sort of a card index system being common. In one works all drawings were kept in a special fireproof room under the charge of one man who acted as a kind of librarian. All drawings were arranged in the order of their numbers in flat drawers, and had on them the pattern number. A description of the pattern was kept in the pattern book, and in addition there were two card index systems, one arranged in the order of the numbers (and containing a description of the drawing), and the other arranged according to the class of work. When a drawing was removed a slip of paper was filled up and placed in a receptacle on the front of the drawer from which the drawing had been taken. All drawings were returned to

this store room at night, but were not replaced if required on the following day, except at the week end, when all drawings had to be returned to their drawers.

In general only blue prints are used in the works, and in many cases no attempt is made to produce elaborate inked-in drawings from which to make the tracings. In practically all cases both the drawing and the tracing made from it are checked.

As regards the drawing office equipment, much variety existed, some works keeping to the old plain boards on horizontal tables, and others again, adopting one of the many forms of sliding boards arranged on a nearly vertical easel.

Working Hours. In practically all American engineering shops work commences after breakfast, usually at seven o'clock, sun time. The men often have a little fruit or lunch whilst at work, but there is no stoppage until dinner time. None of the men would like to commence work before breakfast. Except perhaps in the case of very heavy physical labour, the American plan seems to be a distinct improvement over the English plan of starting before breakfast. The men work better and the hours are more convenient under the former arrangement. The dinner time allowed varies from half an hour to an hour. Most shops still work on Saturday afternoons during all but the summer months, but this will die out.

CHAPTER VII.

Electricity Power Stations.

In the States there are two features of Electrical Station work which are almost non-existent in England. The first is the use of water power, and the other the transmission of electricity over very long distances.

Water Powers. The development of water power has been aided by three factors. In the first place there are a fair number of water powers sufficiently large to be worthy of the attention of engineers of the very front rank, and secondly, near enough to existing or suitable manufacturing and residential districts to make their development a probable commercial success. Also there are several districts in which mining or other properties make the provision of an adequate power service very desirable. These three factors are lacking in England. We have no very large water powers, and no isolated mining or manufacturing districts of consequence.

American water powers naturally divide themselves into two classes: one having very high falls and the other low falls, but (as a rule) large quantities of water. For high heads turbines of the pelton wheel type are almost universal. These high heads are mainly confined to the Western States, heads of 1,500 feet being sometimes obtained. In most instances these heads have not been obtained without building canals, flumes or pipe lines round or through natural obstacles to some point at which the requisite drop in the ground to a river bed is available. High waterfalls ready for harnessing are almost unknown.

As a general rule a stream is tapped at a high altitude and conveyed in a flume along the hillsides to some convenient spot, often many miles distant, and then pipes convey the water down the hillside to a power house situated on the banks of a stream in the gorge below. In most of these plants capital outlay has to be kept down as much as possible, and the flume is consequently very cheaply made. Some of it is dug out of the ground, but much of it is built of planks supported on a wooden trestle. The flumes are carefully watched for troubles.

The pipe line down the hillside to the power house is not free from troubles. These troubles are due partly to the intake getting clogged with leaves and other obstructions, but mainly to water ram caused by fluctuations in the quantity of water taken by the water wheels in the power house. In order to avoid these troubles the nozzles discharging water against the buckets of the wheels are generally made to swivel, and when the load is reduced the excess of water coming through the pipes is turned across the gorge by swivelling the nozzle. Safety valves are also generally used, but these do not prevent water ram, they only reduce its amount. For medium falls—usually in conjunction with ordinary turbines—vertical standpipes open at the top to the atmosphere are placed on the pipe line near the turbines to prevent undue pressure rises. These standpipes are not very satisfactory, however, and at one large power house on the Pacific coast the writer was told that it was contemplated replacing the pipe line by an open canal cutting right up to the power house.

For low and medium heads, turbines as distinct from pelton wheels are used. The higher heads are usually obtained in mountainous districts and predominate in the western states. The low heads are usually found in the

eastern and central states, although there is no strict allotment of territory.

Water power cannot very well be transmitted over long distances, as such. Consequently, if the electricity is to be used at all it must be transmitted to the customer or he must be brought to the water power. Both these results are observable in the States. In the early days of the development of the Niagara power almost none was transmitted further than Buffalo, about 22 miles away. Those who wanted Niagara power had to go to Niagara. Within the last year, however, a transmission line has been erected from Niagara to Toronto, a distance of about 85 miles, and others to go still further afield are projected. The general tendency in hydro-electric development in the States has been for the water power to be developed to meet the wants of customers already in existence or projected, but resident in some previously selected place. Naturally the first water powers to be developed were those in close proximity to these customers, but improvements in electrical science, fostered by high prices for fuel, have led to the transmission of electricity from water powers to customers at great distances, in several instances exceeding 100 miles.

High Voltage Transmission. The transmission of electricity over long distances is only practicable when very high voltages are employed. At low voltages the weight of copper in the conductors would be prohibitive. The rough rule as to voltage in the States is 1,000 volts per mile of transmission with, however, nothing at present above 60,000 volts, although one plant has been constructed with a view to the ultimate adoption of a pressure of 80,000 volts.

Most of the troubles at these high voltages occur in the

transmission line. Generation takes place at, say, 2,300 volts, and is then stepped up to the line voltage by transformers, unless the line voltage does not exceed 15,000, in which case the generators supply at full voltage. Some troubles are experienced in the transformers, due in the main to local short circuits between windings; but the line insulation is the weak link in the chain of supply. As yet there is no really reliable insulator for anything above 60,000 volts. When one is obtained voltages will increase. Lightning is a serious trouble on many of these transmissions. It is responsible for many of the transformer breakdowns, insulator failures, and temporary shut downs. No existing lightning arrester seems to be satisfactory in all respects, and some plants cut them out entirely.

Both aluminium and copper are extensively used for the line wires, the determining factors being mainly price and climate. Aluminium wires carry a bigger load of snow and are liable to corrode in sea fogs. This latter point is interesting to us in England.

The periodicity of the current is generally determined by the pre-existing plant of the customers supplied in the first instance, and is usually 60 cycles. For purely transmission purposes, low frequencies are desirable.

Steam Power Stations. The type of station and its equipment depends on the particular conditions to be satisfied, and in view of the many published descriptions of existing stations no good purpose would be served by giving here detailed descriptions of those plants visited by the writer. A few general remarks may, however, be acceptable.

Buildings. For the buildings a steel framework with brick weather walls is very common but not universal. As

far as possible inflammable materials are excluded. The boilers are very often placed over a basement and not directly on the ground. The basement serves, as a rule, for pumps, fans, and other auxiliary apparatus, whilst over the boilers are usually placed the coal bunkers. In several of the newer power stations there are two decks of boilers, one above the other. This plan may involve some slight extra risk, but is adopted largely on account of the saving in floor space in large towns, and also where the engine-room is small relative to the boiler-room, as where turbines are adopted. The boiler-house itself becomes rather expensive, and is probably not justified where land is very cheap. Another way of accommodating the boilers to a small engine-room is to arrange them in rows end on to the engine-room. The boilers themselves are generally water-tube boilers, and seldom have an economiser fitted.

Switchboards. The switchboard is usually on a gallery overlooking the engine-room floor, although in large units the main switches are frequently at some distance away, and are merely controlled from the switchboard gallery. Most of these controlling arrangements are electrical in their operation, and are well known in England.

In one case—the new power house of the Ontario Power Co. at Niagara Falls—the whole of the switchboard, including the control board, is situated in a house some distance from the power house itself. The advantage of having the switchboard overlooking the engines is that the attendant is immediately made aware of any trouble with the generators and often can take immediate steps to remedy it or safeguard the plant.

With the attendant in a separate room difficulties arise. There is more chance of a misunderstanding between himself and the engine-room staff, especially at those critical

times when every moment counts. It is claimed, on the other hand, that this separation removes him from the strain on his nerves which bursting steam pipes or fly-wheels entail. Yet how many power house troubles are of this drastic nature? Most of them are such as to give rise to no danger—unless of an electrical nature—to the switch-board attendant, and in most cases his nerves will be more roughly handled if he has to depend for guidance in critical moments solely on the apparently conflicting movements of several instrument pointers or the lighting of different coloured lamps.

Then, too, no operator can—it is a physical impossibility—keep his eyes continuously and without intermission on a number of more or less scattered instruments. He requires some relief from such a strain, and at the same time a substitute which will tell him instantly of trouble. Such a substitute is provided by the sights and sounds—particularly the latter—of an engine-room.

The Unit System. Most new power stations are built on the so-called unit system. Each generator is provided with a complete and independent set of boilers, engine, auxiliaries, piping and connections. To a very considerable extent, however, the expression "unit system" is misleading. Practically the only new thing about the system is the provision of certain boilers for each engine, and in the steam and other piping connections to the engines and auxiliaries. Perhaps, too, the provision of separate exciters may be considered a feature of the unit system.

In the older power stations all the boilers fed into one common header—often in duplicate to guard against a shut down—which not infrequently formed a complete ring. From this header all the engines took steam. In the unit system there is no ring steam main and the

common header is smaller than under the old system. The separate engines each have their own boilers, but these are usually connected so as to permit, when desired, of cross connection. It is this cross connection which forms the common header of the unit system. In theory these cross connections are not intended to be used under normal working conditions. As a matter of fact the valves in these connections are usually kept open and only closed when required, so that the term unit system is rather misleading. The reason for keeping these valves open is that a little trouble with one engine or generator may necessitate throwing in another whose boilers are cold or opened up for cleaning and repairs, at very short notice. Where there are a large number of units the cross connections can without much inconvenience be kept closed under ordinary conditions.

The expression unit system applies more to the design than to the operation of most power stations. From that point of view it has some obvious advantage.

Auxiliaries. Although in many respects an ideal method of driving the usual station auxiliaries is by means of electric motors, yet the method increases the risk of a total shut down and delays the starting up after a shut down.

So serious is this trouble that in some of the large New York power stations most of the motor-driven auxiliaries have been replaced by steam-driven ones. This applies in particular to the condenser auxiliaries and the exciter sets. If all electric current is shut off it is obviously a matter of some little time before the generators can be delivering current when the excitation necessary to give this current has to be obtained from the current itself with a number of transformations in between. As regards economy it is probable that the motor-driven sets—except in very large

installations—are slightly superior to the others, but on the other hand they cost much more, and for intermittently running plant this is the more important factor.

Main Units. The high speed engine is little known in the States, and in its stead we have the almost universal adoption of the corliss engine. Corliss engine speeds average somewhat higher than with us. Thus in one large power house there were eight corliss engines of 2,000 and 3,000 horse power each, all running at 94 r.p.m., although this is somewhat higher than is usual, and much below what is occasionally met with.

The steam turbine is now making a strong bid for the position of standard type of prime mover for all sizes above about 500 kilowatts, although the gas engine is being talked about seriously.

The generators are much like those well known in England through the British Westinghouse Co., and the British Thomson-Houston Co.; with this difference, that the American standard frequencies are 25 and 60 cycles per second, instead of 25 and 50. The standard voltages are 2,300 for single-phase distribution, and 6,600, 11,000 and 15,000 for 3-phase transmission over distances up to 10 or 20 miles. Above that distance 30,000 volts or upwards is generally adopted.

Distribution. For house distribution the three-wire system—commonly called the Edison system in the States, and the Hopkinson system in England—is almost universal with 220 volts, or thereabout, across the outers. This is just half the voltage in common use on this side of the Atlantic. The Americans are convinced of the advantages of their lower voltage. Its chief advantage is that low voltage lamps are more efficient than high voltage ones, and its chief disadvantage the cost of the extra copper

required in the conductors. The present writer intended making a comparison between the two on a commercial basis, but time has not, as yet, permitted it. One or two points may, however be mentioned.

In the first place the saving in current will obviously be proportional to the total candle-power hours burned, whilst the extra cost of the copper will depend on the maximum steady load—even though of comparatively short duration—to be provided for. Now, ordinary lighting load factors are very small, and this is at once a point in favour of the higher voltage. On the other hand it may well be that where the load factor is high—as in some works and stores—the saving in current may more than counterbalance the extra investment costs. The matter is one admitting of direct, though not very precise, calculation.

In connection with lamps reference may be made to the practice, common in the States, whereby the electricity supply company gives free renewals of lamps. When a lamp begins to blacken the customer takes it to the company's office and receives in exchange a new lamp free—of course he pays for it indirectly. It is hoped by this means to maintain the efficiency of the light-producing power of the lamps and to ensure that customers shall be provided with reliable and economical lamps.

Alternate Current Supply. Alternating current supply is quite common in the States. As a rule the wires distribute the current at 2,300 volts single phase—not necessarily generated as single phase—by means of overhead wires to transformers which are usually carried on poles and serve to step the voltage down to 220 across the outers of a three-wire system.

In the centres of large towns the wires have often to be laid underground and the system is then very commonly

a direct current one similar, save as to voltage, to that in use in most English towns. This point is illustrated by the table given below, which is taken from a paper by Mr. A. Dow, read at the International Electrical Congress held in St. Louis in 1904.

Town.	Population. 1903-4,	Area in Sq. miles.	D.C area.
Boston	600,000	43	3·6
Buffalo	425,000	51	5
Chicago	2,230,000	190	12
Cleveland	426,000	33	1·5
Detroit	317,000	29	3·2
New York (Manhattan)	1,900,000	22	15·5
Philadelphia	1,700,000	129·5	3
St. Louis	612,000	62·5	7·5

NOTE.—In all the above towns the built-up areas round the central districts are supplied with D.C. In Manhattan all the built-up district is supplied with D.C.

The use of alternating current is in the main confined to the more sparsely built-up districts, especially if mainly residential in character. The advantages of such a system are:—

(1) Low capital cost.
(2) Reduced operating costs.
(3) Simplicity.
(4) Flexibility.

Probably the low capital cost is its strongest point. This is largely due to the absence of substations and rotary transformer machinery. This latter is also responsible for the reduced operating costs. Where the load is mainly a lighting load the all day efficiency of the transformers is rather poor, but is high where the load factor is good. Its

simplicity and flexibility are obvious but, on the other hand, it is not very suitable for some power purposes, owing to the approximate constancy of the motor speed.

Load factor. The influence of load factor on the cost of production—whether of electricity or more material things—is generally recognised nowadays, but a few words here are desirable on two phases of this subject, which have received little attention.

The definition of load factor* ordinarily understood is misleading when we come to consider the economics of an equipment. All plant installed has to be paid for, and its fixed charges require to be met whether the plant is used always, occasionally, or never. Hence from an economic point of view, load factor ought to be understood as the ratio of *average yearly load* to maximum rated capacity of the plant.

Economies in fuel, water, etc., are in general obtained by installing a more expensive plant. The question arises, at what point does this extra expense cease to be justified by the superior economy attained. Clearly when the last extra economy is just equal to this last extra expense—expressed in terms of the fixed charges on the extra capital outlay. Put mathematically, this occurs when the rate of increase in the fixed charges is just equal to the rate of decrease in the fuel—including water and stores—cost.

This is not the same thing as having the total fixed charges equal to the total saving in fuel as is often implied by engineers when discussing, for instance, the best vacuum for use in any given installation of steam engines.

The main point which is at once obvious in this connection is that since the saving depends on the price of fuel,

* Ratio of average to maximum actual load carried by the machines.

water and stores, and also upon the load factor, then clearly the extent to which refined and efficient (in the limited sense) plant is justified, will depend mainly on these two factors: price of fuel and load factor.

For instance, suppose that the difference in the cost of two engine equipments (including all related expenses such as buildings and auxiliaries) is £2,000 or equal to, say, £240 per year in fixed charges. The more expensive equipment causes a saving in coal—for simplicity we will neglect water and stores—amounting to 24 tons per year for each one per cent. of load factor, or 2,400 tons per year if run continuously at full load. Suppose coal costs ten shillings a ton at the fires, then evidently unless 480 tons are saved per year the more expensive plant is not justified. This requires a load factor of 20 per cent. On the other hand if the coal had cost 20 shillings a ton, a ten per cent. load factor would justify the adoption of the more expensive plant.

As a general principle then, we may say that the higher the price of fuel and the higher the load factor, the more likely is an expensive and (thermally) efficient plant to be justified.

In most electricity stations there is a peak in the load curve, and much of the plant is only in use for a few hours a day. In such cases cheap plant is often quite justified. For instance, steam turbines could in many cases be installed for the day load and reciprocating engines running at low vacua or non-condensing used to assist at the peak loads. Again, mechanical stokers are in many cases quite uneconomical for use with boilers which will only be required at the peak loads. In the first place the fixed charges are heavy and the saving small, whilst in most

cases a somewhat smaller boiler plant can be used if hand stoking is employed, because the boilers can be more easily forced.

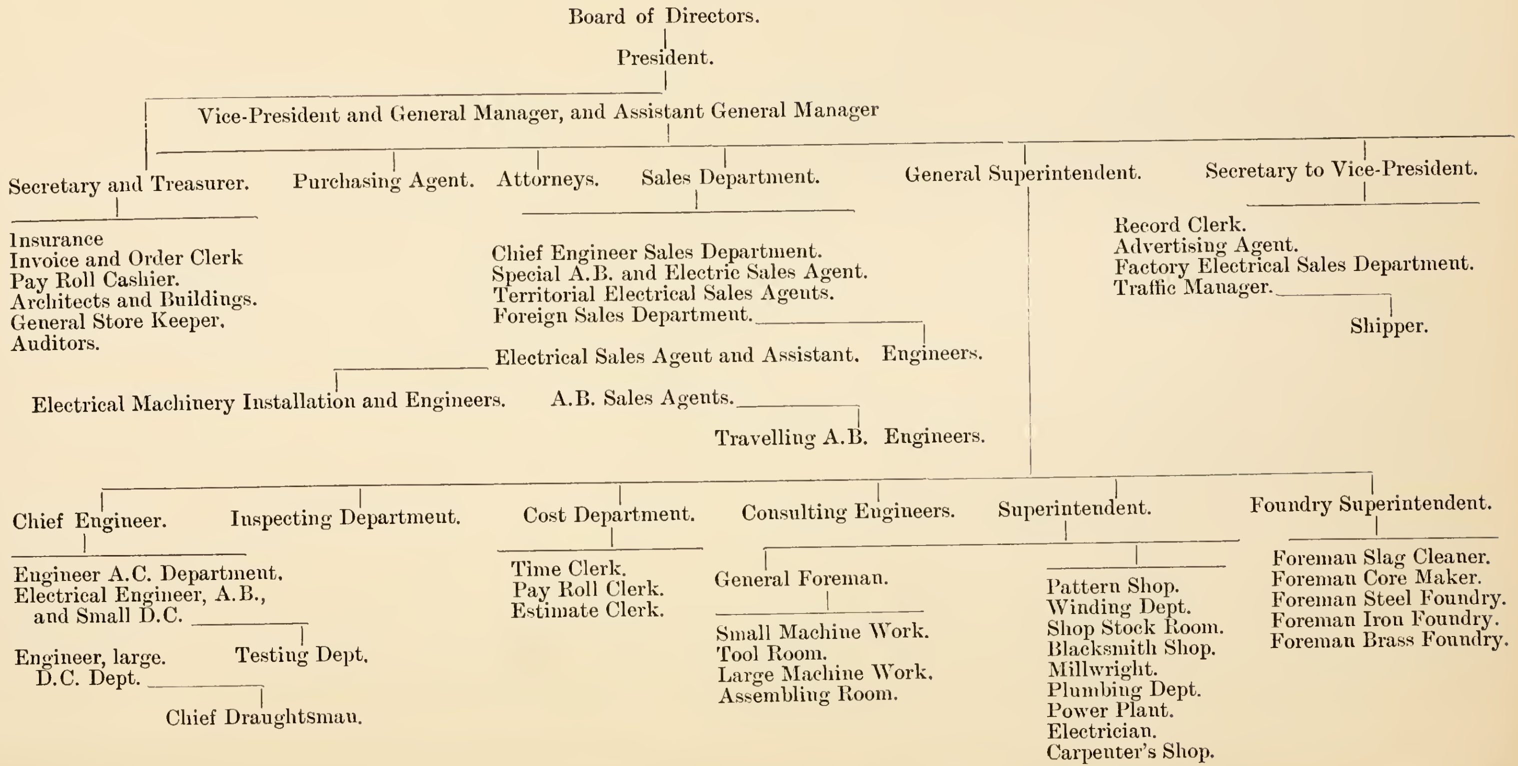
Each case requires careful consideration in view of the particular facts of the case, but it frequently happens that economic considerations are overlooked in a desire to be "up-to-date" and to have a uniform equipment throughout.

Storage Batteries. The use of a booster in series with a battery placed across the mains of an electricity network is unusual in the States, end-cell control being used instead. The advantage of the American method is in reduced first cost, simplicity, and perhaps somewhat greater efficiency. Its disadvantage lies in the deterioration of the end cells and the troubles to which they give rise, and also the necessity for human attendance. Also, whereas in England the tendency seems to be towards having the batteries guaranteed by the makers, the practice in the States seems to lean in the opposite direction. In the former case the inspection and upkeep is likely to be thorough, whereas in the latter case everything depends upon the responsible engineer of the plant.

Business Getting. Within the last year or so, there has been a great increase in the attention given to methods of increasing central station electricity business in the States. Methods vary, novelty being apparently a recommendation, but the use of attractively got-up pamphlets and periodicals for distribution is very common. Personal solicitation is also much adopted, and also extensive general advertising. Persistent attempts are frequently made to induce people to install small electric heaters, fans, and motors for domestic use. Although an increase in the amount of power sold is, generally, in itself an end worth attaining,

yet it is even more desirable that attention should be paid to the character of the new load with a view to increasing the station load factor. A low load factor will keep up prices and act as a deterrent on possible customers, whilst a high load factor will have just the opposite results. In connection with business getting in the States, it may be noted that the competition of gas is not so strong as in England.

ORGANISATION CHART OF X ELECTRIC COMPANY, U.S.A., 1903.



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